

A Trace Element Emission Study  
at  
Selected Sour Gas Plant Incinerator Stacks  
in  
The Province of Alberta

Harmattan - Canadian Superior Oil Limited  
Nevis - Gulf Oil Canada Limited  
Gold Creek - Petro Canada  
Rainbow Lake - Canterra Energy Limited  
Quirk Creek - Esso Resources Canada Limited

for

Energy Resources Conservation Board  
640 Fifth Avenue S.W.  
Calgary, Alberta  
T2P 3G4

by

A.W. Gnyp, Ph.D., P.Eng.  
C.C. St. Pierre, Ph.D., P.Eng.  
D.S. Smith, M.A.Sc., P.Eng.  
S. Viswanathan, Ph.D., P.Eng.

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THE INDUSTRIAL RESEARCH INSTITUTE  
OF THE UNIVERSITY OF WINDSOR

## SUMMARY

The presence and levels of 29 metals in the gases exhausted from incinerator stacks have been established at 5 selected sour gas plants in the province of Alberta. Particulate matter sample collection was in accordance with Alberta Stack Sampling Code procedures. Modifications to conventional equipment were made to improve representative sample collection as well as retention and recovery of captured solid material. Average emission rates of the metals found consistently, at each plant, with glass lined probes, can be summarized according to the scheme:

| Average Emission Rate in grams/hour<br>(Arithmetic Means With Standard Deviations) |           |           |            |              |             |
|------------------------------------------------------------------------------------|-----------|-----------|------------|--------------|-------------|
|                                                                                    | Harmattan | Nevis     | Gold Creek | Rainbow Lake | Quirk Creek |
| Volumetric Flow Rate (acfm)                                                        | 137,500   | 45,600    | 16,000     | 51,500       | 126,800     |
| Metal                                                                              |           |           |            |              |             |
| Aluminum                                                                           | -----     | 18+24     | 4.8 +6.2   | 11+14        | -----       |
| Arsenic                                                                            | 0.12+0.09 | -----     | 0.02+0.01  | -----        | -----       |
| Chromium                                                                           | -----     | -----     | -----      | -----        | 3.5+0.2     |
| Copper                                                                             | 6.3 +5.8  | -----     | -----      | -----        | -----       |
| Iron                                                                               | 640+1000  | 16+11     | 0.62+0.29  | 1.5 +0.5     | 4.0+1.4     |
| Mercury                                                                            | -----     | -----     | -----      | -----        | * 5.8+9.7   |
| Manganese                                                                          | 3.2 +3.8  | 0.24+0.01 | -----      | -----        | -----       |
| Nickel                                                                             | 4.4 +0.06 | -----     | -----      | -----        | -----       |
| Zinc                                                                               | 150+250   | 1.9 +0.2  | 0.24+0.15  | 0.12+0.05    | 2.2+1.8     |

\* Additional sampling scheduled for November 1986 to confirm these anomalous results

It is recommended that atmospheric dispersion modelling of the emissions from the five plants under investigation be carried out to establish their impacts on receptors at ground level. Serious consideration should be given to the implementation of a comprehensive ambient air sampling program in areas where trace element concentrations are projected to be independent of sour gas plant emissions in order to assess typical background levels of metals in different regions of Alberta.

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## I. BACKGROUND

This study was initiated in response to a request by Dr. H.F. Thimm, Senior Environmental and Technical Advisor, Environment Protection Department, Energy Resources Conservation Board (ERCB) on February 17, 1983. The objectives and scope of this work were reviewed and defined in group discussion and telephone conversations by Dr. H.F. Thimm, Dr. A.W. Gnyp, P.Eng., and Dr. C.C. St. Pierre, P.Eng., of the Department of Chemical Engineering, University of Windsor.

In order to formulate a work plan, the earlier sampling programs at the following sour gas plants were reviewed in detail:

- Gulf - Strachan (1)
- Canterra - Ram River (1)
- Shell - Jumping Pound (1)
- Shell - Waterton (2)
- Gulf - Pincher Creek (2).

A formal proposal was submitted to ERCB on March 8, 1983.

### A. OBJECTIVES

The objectives of this investigation were to:

- conduct a trace element emission study at incinerator stacks of the sour gas plants identified as:
  - Harmattan
  - Nevis

- Gold Creek
- Rainbow Lake
- Quirk Creek
- collect atmospheric dust samples with hi-vol samplers, for analysis only if source sampling data showed any severe irregularities
- conduct a 3-month shelf-life study of 0.1 M and 6 M nitric acid solutions containing "low" and "high" levels of the metals of interest to the trace element emission study.

#### B. SCOPE

As a result of the meeting at the University of Windsor with Dr. H.F. Thimm on December 16-17, 1982 and a review of the 1982 sampling activities (1,2), the testing program was divided into five distinct parts.

##### 1. Preliminary Site Inspections

Preliminary site inspections were conducted at all designated sour gas plant incinerator stacks by D.S. Smith, P.Eng., and/or S. Viswanathan, Ph.D. to obtain the pre-test information specified by the Alberta Stack Sampling Code(3).

##### 2. Preliminary Source Tests

Preliminary source testing was carried out at each incinerator stack to obtain:

- the gas stream composition in terms of water vapour, carbon monoxide, carbon dioxide, nitrogen, argon, oxygen and sulphur dioxide
- an estimate of total particulate concentration in the exhaust stream using an approved stack sampling train
- the velocity distribution and total volumetric flowrate at the sampling port elevation
- an estimate of the total particulate emission rate.

These preliminary tests were necessary in order to facilitate isokinetic sampling of all stacks in accordance with the Alberta Environment Source Sampling Code(3).

### 3. Trace Element Emission Measurements

A minimum of three complete particulate emission tests were conducted at each of the five designated sour gas plant incinerator stacks using sampling procedures and equipment consistent with Alberta Environment requirements(3) or as mutually agreed to with Dr. H. Thimm, Energy Resources Conservation Board.

Sample recovery was done in four distinct parts involving:

- nozzle-probe washings
- filter catch
- impinger assembly catch
- cold trap catch

in order to provide an approximation of the particle size distribution and separation of gas phase versus solid phase



trace elements in terms of the location of sample deposition in the train.

Each complete test provided:

- gas stream composition in terms of water vapour, carbon monoxide, carbon dioxide, nitrogen, argon, oxygen and sulphur dioxide
- the local velocity distribution and total volumetric flowrate
- suitable samples for elemental analyses
- the individual trace element concentrations
- the individual trace element emission rates.

#### 4. Trace Element Analyses

For every particulate emission test the samples collected in each of the four distinct parts of the train were analyzed for the trace elements listed in Table 1.1. These elements were selected for earlier investigations (1,2,4) after a comprehensive review of open literature and discussions with personnel from Canadian and American regulatory agencies as well as ERCB representatives.

#### 5. Atmospheric Dust Levels

In earlier studies (1,2), high volume dust samplers were used to establish atmospheric dust levels at two mutually agreed upon locations representing urban and rural sites where trace element concentrations were projected to be unaffected by sour gas plant emissions. During this program additional ambient samples were collected in the

vicinities of each of the facilities investigated. Twenty-four hour samples were acquired at each site according to EPA Reference Methods(5) for elemental analysis of the filter catches. It was agreed that analysis of the high volume dust samples would be carried out only if such data were needed to explain any anomalous source sampling results.

TABLE 1.1 Trace Metals of Interest

| <u>Element</u> | <u>(Symbol)</u> | <u>Element</u> | <u>(Symbol)</u> |
|----------------|-----------------|----------------|-----------------|
| Silver         | (Ag)            | Manganese      | (Mn)            |
| Aluminum       | (Al)            | Molybdenum     | (Mo)            |
| Arsenic        | (As)            | Nickel         | (Ni)            |
| Boron          | (B)             | Lead           | (Pb)            |
| Beryllium      | (Be)            | Antimony       | (Sb)            |
| Cadmium        | (Cd)            | Scandium       | (Sc)            |
| Cobalt         | (Co)            | Selenium       | (Se)            |
| Chromium       | (Cr)            | Tin            | (Sn)            |
| Copper         | (Cu)            | Strontium      | (Sr)            |
| Iron           | (Fe)            | Tellurium      | (Te)            |
| Gallium        | (Ga)            | Titanium       | (Ti)            |
| Germanium      | (Ge)            | Thallium       | (Tl)            |
| Mercury        | (Hg)            | Vanadium       | (V)             |
| Indium         | (In)            | Zinc           | (Zn)            |
| Lithium        | (Li)            |                |                 |

## II. SOURCE SAMPLING METHODOLOGY

### A. INTRODUCTION

A literature search and personal discussions with Canadian and United States regulatory personnel indicated that an approved source sampling reference method(s) did not exist for measuring trace elements in stationary source emission streams. Several publications(6-10) and personal contacts(11-13) indicated that many of the potentially hazardous metal species present at trace levels in emission streams are largely of submicron particle size (0.1-1.0 microns in diameter). This size corresponds to the lower collection efficiency of stack sampling train filters and pollution control devices.

The large stack diameters associated with earlier studies (1,2) (up to 20 feet) and elevated stack temperatures (800-1,200°F) presented significant probe design challenges. The most critical problem was successful incorporation of a glass liner which would insure minimal sample contamination and facilitate sample recovery.

In order to develop suitable sampling and analytical methodologies for trace levels of metals the following objectives had to be met:

- collection of a representative sample
- minimization of sample loss in the train and contamination by sampling train components

- quantitative recovery of the sample from all parts of the train
- development of suitable sample pretreatment procedures to achieve solubilization, concentration and negligible interference
- development of suitable analytical procedures to carry out instrumental analysis of trace metals in the presence of unknown amounts of other particulate matter.

Collection of a representative sample and minimization of contamination are discussed here. Every effort was made to follow the Alberta Environment Stack Sampling Code Reference Methods (AERM)(3).

The source testing supervisors, Mr. D. Smith and/or Dr. S. Viswanathan were present for all tests. Both are registered Professional Engineers in the Province of Ontario with post graduate degrees in Chemical Engineering and more than ten years relevant experience. All team members had successfully completed a suitable source sampling course and possessed relevant engineering backgrounds (including Ph.D. and M.A.Sc. degrees).

## B. LOCATION OF SAMPLING PORTS AND POINTS

### 1. Port Location

The sampling ports and platforms were already installed at all sour gas plant incinerator stacks. Their locations

provided the vertical straight lengths downstream and upstream from the nearest flow disturbances listed in Table 2.1.

Table 2.1 Sampling Port Characteristics

| Plant Location          | Stack Diameter (ft) | Number of Ports | Distance to Nearest Disturbance |          |
|-------------------------|---------------------|-----------------|---------------------------------|----------|
|                         |                     |                 | Downstream                      | Upstream |
| Harmattan-Superior      | 8.8                 | 2               | >8                              | >2       |
| Nevis-Gulf              | 4                   | 2               | 5.1                             | >2       |
| Gold Creek-Petro Canada | 3.4                 | 2               | >8                              | >2       |
| Rainbow Lake-Canterra   | 5                   | 2               | >8                              | >2       |
| Quirk Creek-Esso        | 5.8                 | 2               | >8                              | >2       |

The preferred sampling site according to the AERM No. 1(3) is at least eight stack diameters downstream and a minimum of two diameters upstream from the nearest flow disturbance. When these conditions were not satisfied, the number of sampling points was increased above the minimum requirements specified by AERM.

## 2. Port Design

The sampling ports and/or platforms at all plants required a variety of minor modifications in order to support the train monorail, eliminate obstructions in the sampling train travel path and to standardize to 4-inch diameter Schedule 40

male - threaded pipe nipples. Preliminary field inspections were conducted at all sites to allow preparation of engineering drawings and specifications for submission to plant operators who arranged the necessary changes.

### 3. Number and Location of Sampling Points

The number and location of traverse points were determined according to AERM No. 1(3) in order to provide the required number of equal sampling areas, as illustrated in Figure 2.1. When the upstream distance to the nearest disturbance was greater than 8 diameters Table 2.2 was used. For stacks with less than 8 diameter distances, Figure 2.2 was employed to increase the required number of sampling points. Table 2.3 facilitated location of the points on a diameter for up to 24 points per traverse.

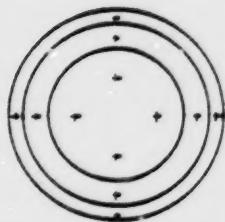
### C. DETERMINATION OF STACK GAS VELOCITY AND VOLUMETRIC FLOW RATE

Method 1 (AERM)(3) was followed during measurement of local stack velocities needed to calculate the total volumetric flowrate through the incinerator stack at the sampling elevation.

All velocity measurements were made using an S-type Pitot tube. A calibrated sheathed resistance thermometer (RTD), attached to the probe assembly, allowed simultaneous temperature and velocity pressure measurements. The Pitot tube coefficients were obtained for all the RTD/Pitot tube/sampling nozzle combinations, as illustrated in Figure 2.3, using the wind tunnel located in the University of Windsor Department of Mechanical



Table 2.2  
Minimum Number of Traverse Points  
for Sampling Stacks (3)



CIRCULAR DUCTS

| Duct Diameter, Ft. | Minimum Number of Sampling Points Required per Traverse   |
|--------------------|-----------------------------------------------------------|
| Less than 1        | 2                                                         |
| 1 < 1.0 ≤ 2        | 4                                                         |
| 2 < 1.0 ≤ 4        | 6                                                         |
| 4 < 1.0 ≤ 8        | 10                                                        |
| 8 < 1.0 ≤ 16       | 16                                                        |
| Greater than 16    | Refer to Alberta Environment for approval before testing. |

1.0 = Inside diameter of stack

Figure 2.1

Cross-Section of Circular Stack Divided into Equal Areas with Traverse Points Located at Center of Each Area

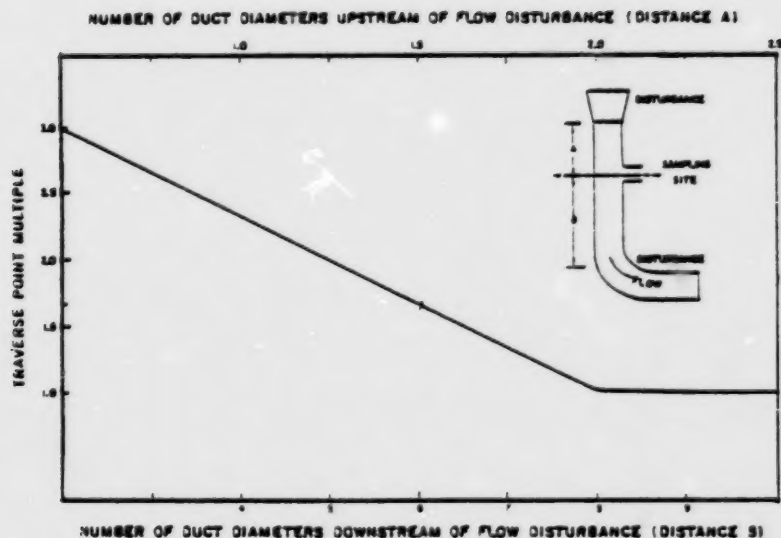


Figure 2.2  
Traverse Point Multiples to Determine Minimum  
Number of Traverse Points Required When  
 $A < 2$  or  $B < 8$  (3)

Table 2.3 Location of Traverse Points in Circular Stacks

| Percent of Stack Diameter from Inside Wall to Traverse Point |                                         |      |      |      |      |      |      |      |      |      |      |      |
|--------------------------------------------------------------|-----------------------------------------|------|------|------|------|------|------|------|------|------|------|------|
| Traverse<br>Point<br>Number<br>On A<br>Diameter              | Number of traverse points on a diameter |      |      |      |      |      |      |      |      |      |      |      |
|                                                              | 2                                       | 4    | 6    | 8    | 10   | 12   | 14   | 16   | 18   | 20   | 22   | 24   |
| 1                                                            | 14.6                                    | 6.7  | 4.4  | 3.3  | 2.5  | 2.1  | 1.8  | 1.6  | 1.4  | 1.3  | 1.1  | 1.1  |
| 2                                                            | 85.4                                    | 25.0 | 14.7 | 10.5 | 8.2  | 6.7  | 5.7  | 4.9  | 4.4  | 3.9  | 3.5  | 3.2  |
| 3                                                            |                                         | 75.0 | 29.5 | 19.4 | 14.6 | 11.8 | 9.9  | 8.5  | 7.5  | 6.7  | 6.0  | 5.5  |
| 4                                                            |                                         | 93.3 | 70.5 | 32.3 | 22.6 | 17.7 | 14.6 | 12.5 | 10.9 | 9.7  | 8.7  | 7.9  |
| 5                                                            |                                         |      | 85.3 | 67.7 | 34.2 | 25.0 | 20.1 | 16.9 | 14.6 | 12.9 | 11.6 | 10.5 |
| 6                                                            |                                         |      | 95.6 | 80.6 | 65.8 | 35.5 | 26.9 | 22.0 | 18.8 | 16.5 | 14.6 | 13.2 |
| 7                                                            |                                         |      |      | 89.5 | 77.4 | 64.5 | 36.6 | 28.3 | 23.6 | 20.4 | 18.0 | 16.1 |
| 8                                                            |                                         |      |      | 96.7 | 85.4 | 75.0 | 63.4 | 37.5 | 29.6 | 25.0 | 21.8 | 19.4 |
| 9                                                            |                                         |      |      |      | 91.8 | 82.3 | 73.1 | 62.5 | 38.2 | 30.6 | 26.1 | 23.0 |
| 10                                                           |                                         |      |      |      | 97.5 | 88.2 | 79.9 | 71.7 | 61.8 | 38.8 | 31.5 | 27.2 |
| 11                                                           |                                         |      |      |      |      | 93.3 | 85.4 | 78.0 | 70.4 | 61.2 | 39.3 | 32.3 |
| 12                                                           |                                         |      |      |      |      | 97.9 | 90.1 | 83.1 | 76.4 | 69.4 | 60.7 | 39.8 |
| 13                                                           |                                         |      |      |      |      |      | 94.3 | 87.5 | 81.2 | 75.0 | 68.5 | 60.2 |
| 14                                                           |                                         |      |      |      |      |      | 98.2 | 91.5 | 85.4 | 79.6 | 73.9 | 67.7 |
| 15                                                           |                                         |      |      |      |      |      |      | 95.1 | 89.1 | 83.5 | 78.2 | 72.8 |
| 16                                                           |                                         |      |      |      |      |      |      | 98.4 | 92.5 | 87.1 | 82.0 | 77.0 |
| 17                                                           |                                         |      |      |      |      |      |      |      | 95.6 | 90.3 | 85.4 | 80.6 |
| 18                                                           |                                         |      |      |      |      |      |      |      | 98.6 | 93.3 | 88.4 | 83.9 |
| 19                                                           |                                         |      |      |      |      |      |      |      |      | 96.1 | 91.3 | 86.8 |
| 20                                                           |                                         |      |      |      |      |      |      |      |      | 98.7 | 94.0 | 89.5 |
| 21                                                           |                                         |      |      |      |      |      |      |      |      |      | 96.5 | 92.1 |
| 22                                                           |                                         |      |      |      |      |      |      |      |      |      | 98.9 | 94.5 |
| 23                                                           |                                         |      |      |      |      |      |      |      |      |      |      | 96.8 |
| 24                                                           |                                         |      |      |      |      |      |      |      |      |      |      | 98.9 |

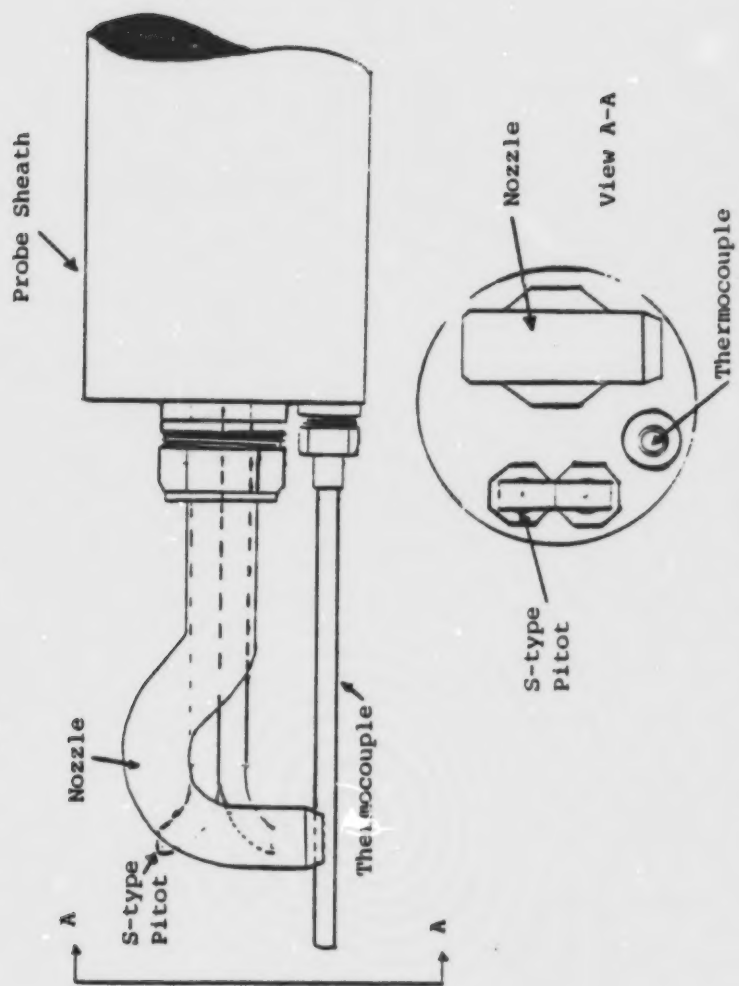


Figure 2.3 Relative Position of RTD/Pitot Tube/Sampling Nozzle  
Used in Calibration and Sampling

Engineering. The procedure described in Appendix 2A, Method 2, of the Ontario Source Testing Code(14) was followed.

An inclined manometer with a readability of 0.1 inches of water was employed to measure the velocity pressure. Barometric pressures were obtained from the plant laboratories for each sampling period.

The absence of cyclonic and/or flow reversals was confirmed at all sampling locations.

D. DETERMINATION OF STACK GAS COMPOSITION AND MOLECULAR WEIGHT ON A DRY BASIS

The molecular weight of the exhaust gas stream on a dry basis required for use in Method 5 (AERM)(3) was calculated employing on-site gas chromatographic analyses.

1. Gas Chromatographic Analyses

Integrated ten minute samples were collected by drawing air with a Neptune Model 4K vacuum pump into an 18 litre Tedlar sampling bag. The gas composition in terms of carbon dioxide, carbon monoxide, oxygen, and nitrogen was determined with a Carle Model AGC III gas chromatograph equipped with 1/4-inch by 2-foot long Porapak Q (100-200 mesh) and 1/4-inch by 6-foot long molecular sieve 13X columns. One side of the thermal conductivity detector was located between the Porapak Q and molecular sieve columns while the other side was at the outlet of the molecular sieve column. The instrument, operated isothermally at 55°C with a helium flowrate of 40 cm<sup>3</sup>/min, was

calibrated with a known mixture of nitrogen, oxygen, carbon dioxide, and carbon monoxide. The standard gas was prepared by DB Robinson & Associates, Ltd. of Edmonton, Alberta. Appendix I documents the composition of the standard gas.

Analysis was performed on 1000 microlitre injections immediately following each test run.

## 2. Sulphur Dioxide

Sulphur dioxide concentrations in the exhaust stream were obtained by following Method 5 (AERM)(3) for sulphur dioxide emission measurements only. A constant sampling rate of approximately 0.1 cubic feet per minute was employed to provide total sample volumes of 2 to 6 cubic feet. After sampling, the two midjet impingers containing 3% hydrogen peroxide were transferred, along with impinger rinses, to 25 mL glass sample vials fitted with Teflon caps.

In the laboratory, analysis was accomplished by the technique outlined in Method S308 of the NIOSH Manual of Analytical Methods(15), in which isopropyl alcohol is added to the samples. The pH of each sample is adjusted with perchloric acid, and the sulfate content of each sample determined by titration with barium perchlorate solution using Thorin indicator. Results of analyses (calculated as  $\text{SO}_2$ ), which include any necessary correction for blank determinations run in parallel with the analysis, were used in conjunction with field sampling data to calculate the reported concentrations of sulphur

dioxide. This analytical method is consistent with Method 5 (AERM)(3) requirements.

#### E. DETERMINATION OF MOISTURE CONTENT

The moisture content of a stack gas was obtained employing the condensation method of Method 3 (AERM)(3). This determination was made simultaneously with the particulate (trace element) sampling programme.

The mass of condensate collected in the impingers and dessicant (Drierite) was determined by weighing all containers before and after sampling to the nearest 0.1 g.

This water mass was converted to an equivalent gaseous volume. The volume fraction of moisture in the stack gas was calculated using the corresponding total gas sample volume at reference conditions (530°R, 29.92 inches Hg).

#### F. DETERMINATION OF PARTICULATE EMISSIONS

The measurement of particulate emission rates according to Method 4 (AERM)(3) requires isokinetic sampling and particulate separation from the extracted gas stream using dry filter media and wet scrubbing in a series of impingers, using the basic sampling train illustrated in Figure 2.4. In order to extract and transport the samples from the stack to the collection media with minimal contamination, a glass liner was used. For sour gas incinerator stacks, having gas stream temperatures in the 800 to 1200°F range, a custom gas cooled probe was designed and constructed. The use of acid solutions in the impingers and the

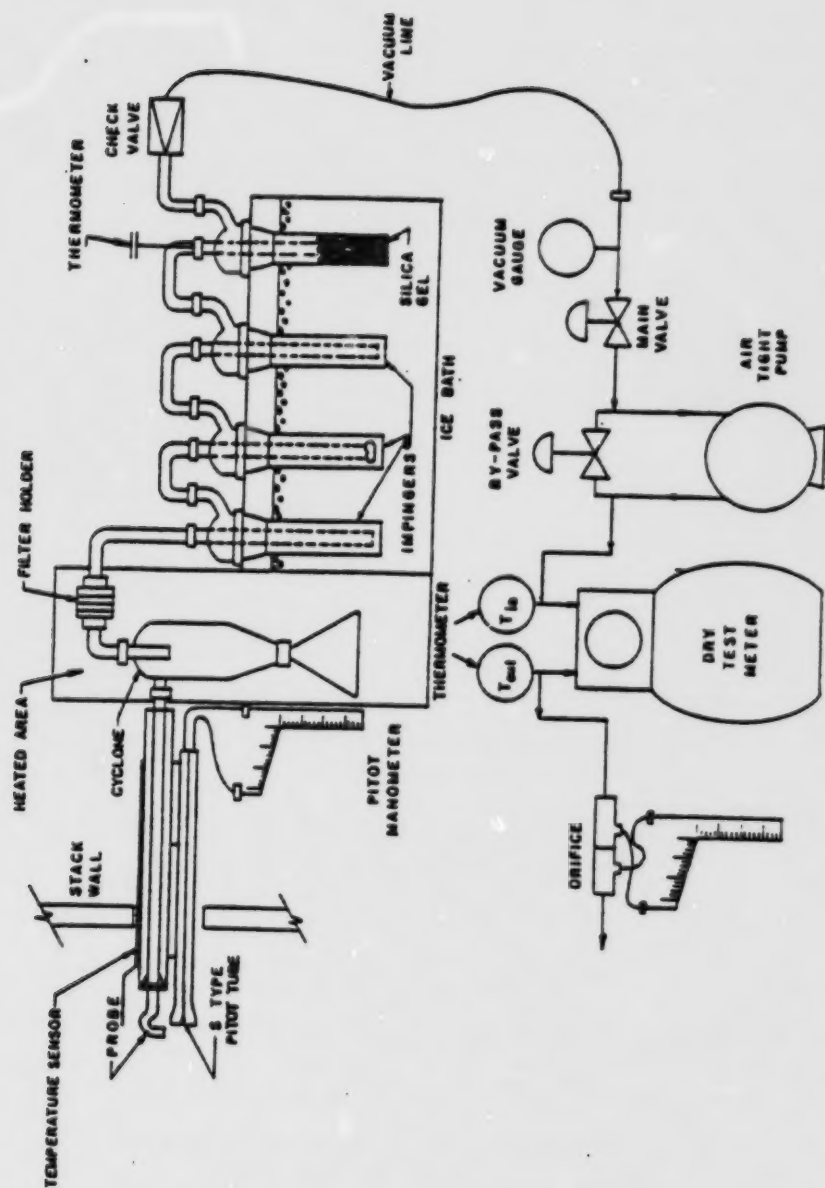


Figure 2.4 Basic Sampling Train for Particulate Matter



addition of two impingers kept at the dry ice-acetone temperature, helped to promote submicron particulate collection.

The recommended isokinetic sampling procedures of AERM No. 4(3) were followed for all particulate emission tests. Preliminary tests were not always isokinetic. Sample recovery and analyses, which were much more rigorous than those required for the usual particulate matter sampling tests, are described in detail in the next two sections.

All substantial modifications to the sampling apparatus and procedures of Method 4 are described in detail here. The choice of components and absorbing solutions represents an optimum in terms of a single procedure for sampling and pretreatment of all the elements of concern, although, such pretreatment might not be best on an individual element basis.

#### 1. Apparatus

The sampling train employed is schematically illustrated in Figure 2.5.

##### a. Pitot/Probe Assembly

A custom air cooled probe was fabricated in the University of Windsor, Chemical Engineering Workshop, by Mr. G. Ryan. Figure 2.6 details the probe in cross-section and plan. A sheathed, remote temperature device (RTD) capable of withstanding the high gas stream temperatures and compatible with the existing electronics of the temperature readout unit was incorporated into the probe assembly.



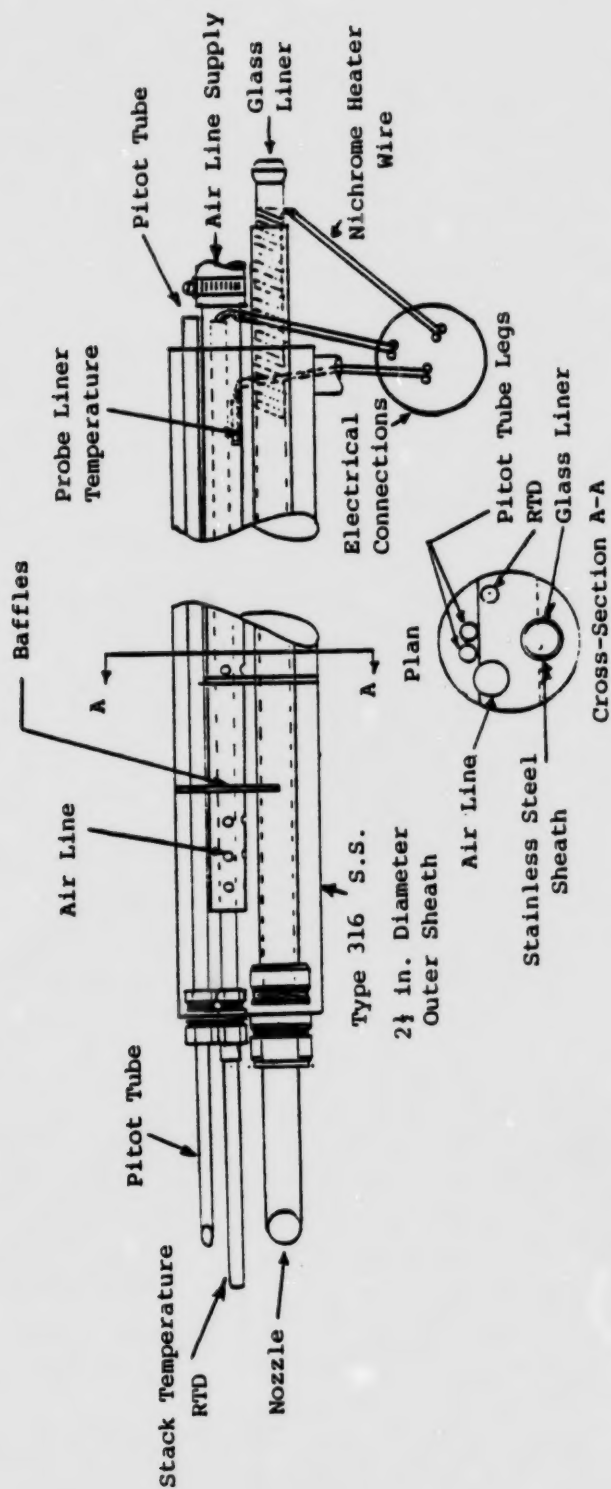


Figure 2.6 Plan and Cross-Sectional Views of Air Cooled Probe

Sampling nozzles of the button-hook type were constructed of 316 stainless steel. They were the only components of the train not made of glass that contacted the extracted gas sample stream.

Borosilicate glass was selected for the 5/8-in. glass probe liners since it could withstand more mechanical and thermal shock than Vycor.

The approximate composition of the borosilicate glass probe is provided in Table 2.4. Tests have shown(16) minimal trace element leaching by acidic solutions similar to those employed during this study for sample recovery.

The annular flow area between the outer stainless steel sheath and inner protective tube containing the glass liner was baffled to enhance heat removal. The back half of the probe was wound with Nichrome heating wire to ensure that no condensation occurred in the probe length exposed to the ambient atmosphere. Cooling air was provided by a self-contained Fuji Ring Compressor Model VFC 302P-5T centrifugal blower with a capacity of 30 cubic feet per minute or plant compressed air supplied at the sampling platform level. The cooling air flow rate was adjusted to achieve the necessary balance between heat removal consistent with glass probe liner protection and excessive cooling leading to possible condensation.

All Pitot-RTD-nozzle combinations were calibrated (for all possible sampling nozzle diameters) prior to and following field

Table 2.4 Approximate Composition and Physical Properties  
of Borosilicate Glass Probe(17)

Composition (%) by weight

| SiO <sub>2</sub> | B <sub>2</sub> O <sub>3</sub> | Al <sub>2</sub> O <sub>3</sub> | Na <sub>2</sub> O | K <sub>2</sub> O |
|------------------|-------------------------------|--------------------------------|-------------------|------------------|
| 80.5             | 12.9                          | 2.2                            | 3.8               | 0.4              |

Physical Properties

| Softening<br>Temp. of | Annealing<br>Temp. of | Strain<br>Temp. of | Maximum<br>Temp. of | Specific<br>Gravity | Coefficient of Linear<br>Expansion F <sup>-1</sup> x10 <sup>7</sup> |
|-----------------------|-----------------------|--------------------|---------------------|---------------------|---------------------------------------------------------------------|
| 1508                  | 1027                  | 950                | 932-1022            | 2.23                | 18                                                                  |

use to derive the S-type pitot tube coefficients corresponding to actual use in the sampling programme(14).

b. Filter and Cyclone

A cyclone was not used as a sampling train component since previous studies (1,2) indicated that particulate sizes were not sufficiently large to be captured by the normal cyclone design employed in stack sampling trains. The glass probe liner was connected directly to the 12.5 cm diameter filter holder with a cyclone by-pass constructed of Pyrex glass.

Several filter media have collection efficiencies greater than 99% (for 0.3 micron dioctyl phthalate particles) for face velocities of 12 to 125 cm/s. The conventional glass fibre filter material manufactured by Reeve Angel (Whatman, Inc.) Type 934 AH and the Ultra-Pure QM-A-quartz micro fibre filters, supplied by Whatman were selected for blank metal checks (See Appendix I for technical data). A special run of the 12.5 cm diameter QM-A-quartz micro fibre filters was made by Whatman who supplied 100 without cost for this study.

The QM-A-quartz filters, which were found to have lower trace element concentrations in the series of blank analyses conducted in the laboratory(1), were used in this study. For 0.3 micron dioctyl phthalate smoke particles the QM-A-quartz materials were found to have 99.95% collection efficiency(18).

c. Impinger Train

The order and contents of the normal impinger train specified by AERM No. 4(3) are summarized in Table 2.5.

Table 2.5 Method 4 Impinger Train

| Impinger<br>Number | Type                | Contents<br>g                       |
|--------------------|---------------------|-------------------------------------|
| 1                  | Modified            | 100 distilled<br>deionized<br>water |
| 2                  | Greenburg-<br>Smith | 100 distilled<br>deionized<br>water |
| 3                  | Modified            | Empty                               |
| 4                  | Modified            | 250-dessicant                       |

All impingers were immersed in an ice-water bath to condense water vapour for purposes of determining the moisture content of the gas stream and to enhance capture of submicron particulate passing through the filter.

For this trace element sampling program two additional impingers were added to the basic particulate matter sampling train providing the knock-out and absorption train detailed in Table 2.6.

Although a mixture of nitric and hydrochloric acids would be superior for dissolution of the trace metals, the presence of chloride during evaporation of the excess acid could result in significant losses of volatile halides (arsenic, selenium and vanadium). A six molar nitric acid concentration was chosen



since this strength was successfully employed in an earlier study (6). Eight molar(18) concentrations have also been employed by previous investigators.

Table 2.6 Trace Element Impinger Train

| Impinger<br>Number | Type            | Contents<br>g       | Immersion Bath<br>Temperature(°C) |
|--------------------|-----------------|---------------------|-----------------------------------|
| 1                  | Modified        | 100 6 M nitric acid | 0                                 |
| 2                  | Greenburg-Smith | 100 6 M nitric acid | 0                                 |
| 3                  | Modified        | Empty               |                                   |
| 4                  | Modified        | Empty               | -80                               |
| 5                  | Modified        | Empty               | -80                               |
| 6                  | Modified        | 250-dessicant       | 0                                 |

Deionized, distilled water, provided by the Energy Resources Conservation Board laboratory in Edmonton, was prepared following the procedure outlined in Appendix II. Trace metal grade Baker nitric acid from Lot No. 218042 was used to prepare the 6M solutions. Appendix II summarizes the composition of this reagent.

The last impinger contained Drierite (mesh size 10-20) which was discarded after each run. Loss of moisture removal

capacity and erroneous moisture levels were readily detected by the blue to pink colour change.

d. Control Module

An approved EPA Model No. CU-4 sampling train manufactured by Andersen Samplers, Inc. was employed to sample isokinetically. The Pitot tube coefficients, orifice meter flow factor and dry gas meter correction factor were determined prior to field use employing calibration procedures recommended in Method 7 of the AERM(3). Post calibration of the train was performed at the conclusion of the sampling program.

Isokinetic sampling within +10% at every point on each traverse was verified following the Method 4 procedure.

e. Leak Test

The 8-foot gas cooled probe was leak tested before each sampling traverse following AERM No. 4(3).

### III. SAMPLE RECOVERY

Quantitative recovery of the samples from all parts of the train required a rigorous and meticulous procedure which took 3 to 4 hours to complete.

#### A. INTRODUCTION

Upon completion of a test the main power switch and both flow control valves were closed. After the probe was rotated so that the nozzle inlet faced downstream, the probe assembly was pushed into the stack so that the impinger case was accessible from the sampling platform. Then the oven door was opened. The glassware was allowed to cool and the glass probe liner was disconnected from the cyclone-bypass. After the probe glass ball socket and the cyclone-bypass ground glass joint were sealed the complete impinger case was removed from the traversing rail and safely positioned on the sampling platform.

The probe assembly was then slowly removed from the port while maintaining cooling air flow through the probe jacket. When the probe could be safely handled with high temperature heat resistant gloves it was removed from the port. The nozzle tip was sealed and protective end caps were placed over the nozzle-Pitot-RTD and the ground glass ball socket to prevent physical damage to the exposed parts. Cooling air flow was maintained until the probe could be safely handled with bare hands.

While the probe was cooling the impinger assembly was sealed and lowered to ground level for sample recovery in the laboratory. The probe cleanup, which took place at the sampling platform level, was facilitated by the use of a custom built support system which rode on the traversing rail. A detailed step-by-step cleanup procedure follows for the nozzle-probe, filter, impingers in the ice-water bath and impingers in the dry ice-acetone bath. Figure 3.1 details sample recovery from the component parts of the train.

#### B. NOZZLE-PROBE

For cleanup purposes, the protective caps were removed from both ends of the probe assembly and the sealed nozzle exterior wiped with paper towels.

##### 1. Nozzle

After removing the nozzle and sealing the end of the glass liner, the nozzle was rinsed with 6M nitric acid (see Appendix II) from a polyethylene wash bottle, into a labelled 500 mL sample bottle A1.

The interior of the nozzle was vigorously scrubbed with a nylon bristle brush mounted on a stainless steel wire handle. The rinsing-brushing operations continued until the washings showed no visible particles. Approximately 150 mL more of 6M  $\text{HNO}_3$  were used in this step. All washings were collected in sample bottle A1.



Finally, the nozzle was rinsed with deionized distilled water which was discarded. The clean nozzle was placed into a protective polyethylene bag for use in the next test.

All sample bottles were new and constructed of borosilicate glass with Teflon seals in the screw type caps. Prior to use, the new sample bottles were cleaned in a glass washer with Alconox water solution then rinsed with 6 M nitric acid ( $\text{HNO}_3$ ) and finally with deionized distilled water (see Appendix II). Immediately prior to field use, the bottles were rinsed with 0.1M  $\text{HNO}_3$ .

## 2. Probe

The probe assembly was placed in the support system and the exterior of both liner ends wiped with paper towels. The probe liner was cleaned by first tilting and rotating the probe while squirting approximately 350 mL of 6M  $\text{HNO}_3$  into the upper end. The nitric acid wash was collected in labelled container A1.

Next a nylon probe brush, with Teflon coated stainless steel wire handles and extensions, was used to vigorously scour the liner interior. Another 350 mL of 6M nitric acid were passed through the tilted probe liner, while rotating, and collected into a second container, A2. This procedure was repeated until the washings showed no visible particles. Then the liner was visually inspected to confirm that it was clean and minimal rinse acid was held up in the liner. The probe brush was rinsed into



container, A2 and both sample bottles, A1 and A2 were marked for liquid level and carefully stored.

The liner was rinsed with deionized distilled water which was discarded, both ends sealed and the protected covers replaced.

### 3. Nozzle-Probe Blanks

Before the next test, both the nozzle and probe liner were rinsed with 0.1M  $\text{HNO}_3$  which was collected in labelled container B (100 mL). This blank constituted an additional test for gross contamination which might occur during storage and/or shipment between tests.

The container liquid level was marked and the blank stored for subsequent trace element analysis. The nozzle and probe were rinsed with distilled water and then put together for the test to follow.

## C. FILTER

In the laboratory the filter holder was carefully removed from the oven and separated from the cyclone bypass.

### 1. Filter Removal

The quartz filter was carefully removed from the filter holder using a pair of nonserrated nylon tipped tweezers and a Teflon coated razor blade to lift the filter from the gasket.

The filter, which had been tared to the nearest  $\pm 0.1$  mg at constant weight in a 50 percent relative humidity atmosphere, was placed into a labelled disposable Petri dish made of polystyrene.



Next the gasket was carefully scraped with the Teflon coated razor to remove any filter matter adhering to the surface. This material was added to the Petri dish, which was sealed, then carefully stored for later trace element analysis and final weighing at 50% relative humidity.

## 2. Cyclone-Bypass and Filter Front End

The silicone grease was removed from the ground glass joints and the cyclone bypass rinsed with 6M  $\text{HNO}_3$  into container A2. The front half of the borosilicate glass filter holder was similarly cleaned into the same container. After brushing and rinsing until clean, the final liquid level was noted on container A2.

The cyclone-bypass and filter holder were then rinsed with 0.1M  $\text{HNO}_3$  and deionized distilled water to ready them for reassembly.

## D. IMPINGER TRAIN

The two cold trap impingers (dry ice-acetone bath) were separated from the four impingers in the ice-water bath by removing the glass connections which were placed on disposable polyethylene sheets. The high temperature silicon grease\* was then removed from the ground glass joints on every piece of connecting glassware and impingers using disposable paper towels.

### 1. Moisture Determination

Water was wiped from the outside walls of each impinger with absorbent paper. Then all six impingers were weighed to the

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\*Dow Corning High Vacuum Grease.

nearest  $\pm 0.1$  g on a trip balance to allow stack gas moisture determinations following the condensation method (AERM-3)(3). The Drierite contained in impinger 6 was discarded.

2. Impingers 1,2 and 3 at Ice-Water Bath Temperature

The contents of impingers 1,2 and 3 were emptied into labelled container C1 (and C2 if required). Then 20-30 mL of 6M  $\text{HNO}_3$  from a polyethylene wash bottle were used to rinse each impinger. The rinses were collected into container C1 or a second container C2.

After brushing the inlet and outlet passages of each impinger, they were rinsed again with 6M  $\text{HNO}_3$ . Approximately 25-mL of 6M  $\text{HNO}_3$  were added to each impinger, which was shaken vigorously for 2-3 minutes. The washes were emptied into container C2. These procedures were continued until the surfaces were visibly clean. Normally the total rinse volumes, initial impinger acid charges, and condensed water vapor required two 500 mL sample bottles.

3. Blank-Impingers 1,2 and 3

Before the next test approximately 25 mL of 0.1M  $\text{HNO}_3$  were added to each impinger which was vigorously shaken for 2-3 minutes. The washes were poured into labelled container D to constitute a blank for the next test. This additional step provided a check on possible gross contamination during storage and/or shipment between tests.

Each impinger was then flushed with deionized distilled water which was discarded.

Impingers 1 and 2 had approximately 100 mL of 6M  $\text{HNO}_3$  added to the marked level for use in the next test.

After taring, the water-bath impingers (1,2 and 3) were then assembled for the next test.

4. Impingers 4 and 5 at Dry Ice-Acetone Bath Temperature

The contents of impingers 4 and 5 were emptied into labelled container E. Each impinger was rinsed with 20-30 mL of 6M  $\text{HNO}_3$  with the rinses being added to the sample bottle. Inlet and outlet passages were brushed and a final wash with 6M  $\text{HNO}_3$  was completed in the same manner as for impingers 1,2 and 3.

5. Blank-Impingers 4 and 5

At the start of the next test approximately 25 mL of 0.1M  $\text{HNO}_3$  were added to each impinger which was vigorously shaken for 2-3 minutes. The washes were poured into labelled container F which constituted a blank for the next test. After flushing with deionized distilled water, which was discarded, impingers 4 and 5 were weighed and assembled.

6. Connecting Glassware

The glassware used to connect the impinger train was removed from the disposable polyethylene sheets mentioned earlier and any material adhering to the walls was rinsed with 6M  $\text{HNO}_3$  into appropriate containers. After brushing the walls, the connectors were again rinsed with 6M  $\text{HNO}_3$ . The rinses from glassware connecting impingers 1,2 and 3 were added to bottle C1 or C2 and the rinses from impingers 4 and 5 connectors were added

to bottle E. Final deionized distilled water rinses readied the connectors for the subsequent test.



#### IV ANALYTICAL PROCEDURES

The analytical procedures developed for earlier studies (1,2,4) were applied to the samples collected during this investigation. Atomic absorption spectrometry (AAS) offered the most viable approach to the measurement of the 29 trace elements of concern. Generally, atomic absorption is relatively interference free, however, high concentrations of dissolved salts can produce interference by scattering, particularly when analyses are carried out at UV wavelengths. Although atomic absorption is normally not a sensitive technique for arsenic, selenium and mercury determinations, modification of the standard procedures can lower detection limits by 2 orders of magnitude. For example, furnace techniques can be used to improve analyses for selenium, arsenic and vanadium. The cold vapour procedure has been reported to be a reliable method of determining trace amounts of mercury (6,19,20).

To ensure complete dissolution of all but the most inert metallic species that were collected as particulate matter, it would be desirable to use a mixture of nitric and hydrochloric acids for preparation of the solutions to be subjected to atomic absorption spectrometry. However, the use of hydrochloric acid must be limited to prevent significant losses of the volatile halides of arsenic, selenium and vanadium during the evaporation of excess acid. Consequently, all sample preparation was done in parallel to provide one group of metals in nitric acid and



another in hydrochloric acid. Table 4.1 details the selection of acids for the dissolution of the metals pertinent to this investigation. Also provided are the analytical parameters for atomic absorption analyses.

#### A. PRELIMINARY FIELD TESTING

The samples collected during the preliminary testing of the Canterra - Ram River plant on August 25, 1982 were used to finalize the analytical procedures for all samples acquired during the trace element emission study. These source samples were selected since the filter was coated with a dark deposit and the impinger solutions were straw colored. In order to identify the materials on the filter and in the solutions, specimens were submitted for atomic-absorption (AA), neutron activation (NA) and high performance liquid chromatography (HPLC) analyses.(1)

Figure 4.1 illustrates the steps required to produce solutions for atomic absorption from the filter catch obtained during the preliminary test at Ram River.(1)

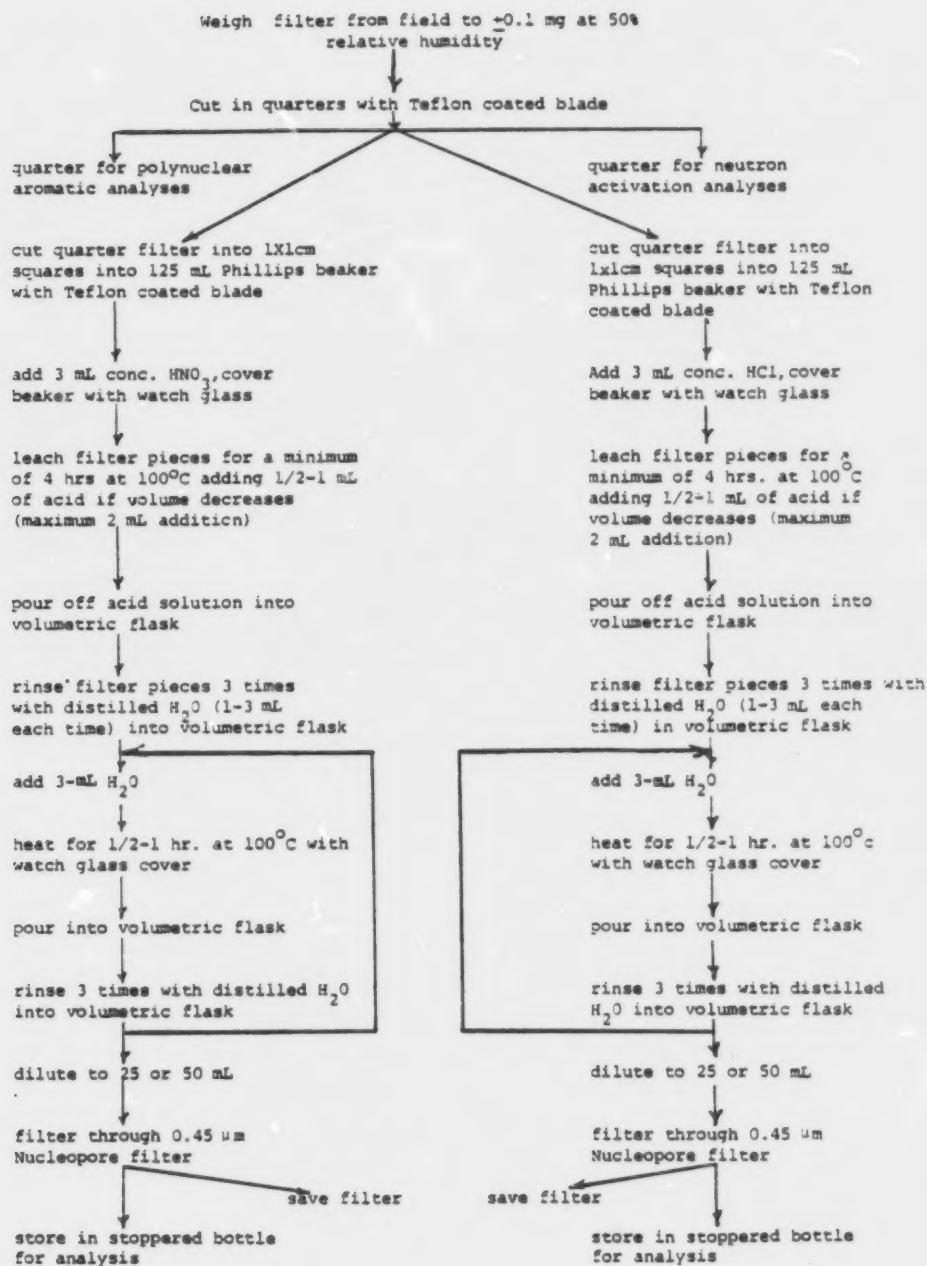
The preparation of solutions from the probe and nozzle wash and impinger contents and washes is depicted in Figure 4.2. In order to establish where significant amounts of material might be collected in the impinger train, the impingers were treated as units involving impinger 1, impingers 2 and 3, and impingers 4 and 5. Twenty or 30 millilitre aliquots were taken from each unit for the initial analyses.(1)



Table 4.1 Summary of Analytical Parameters  
for Atomic Absorption Analysis

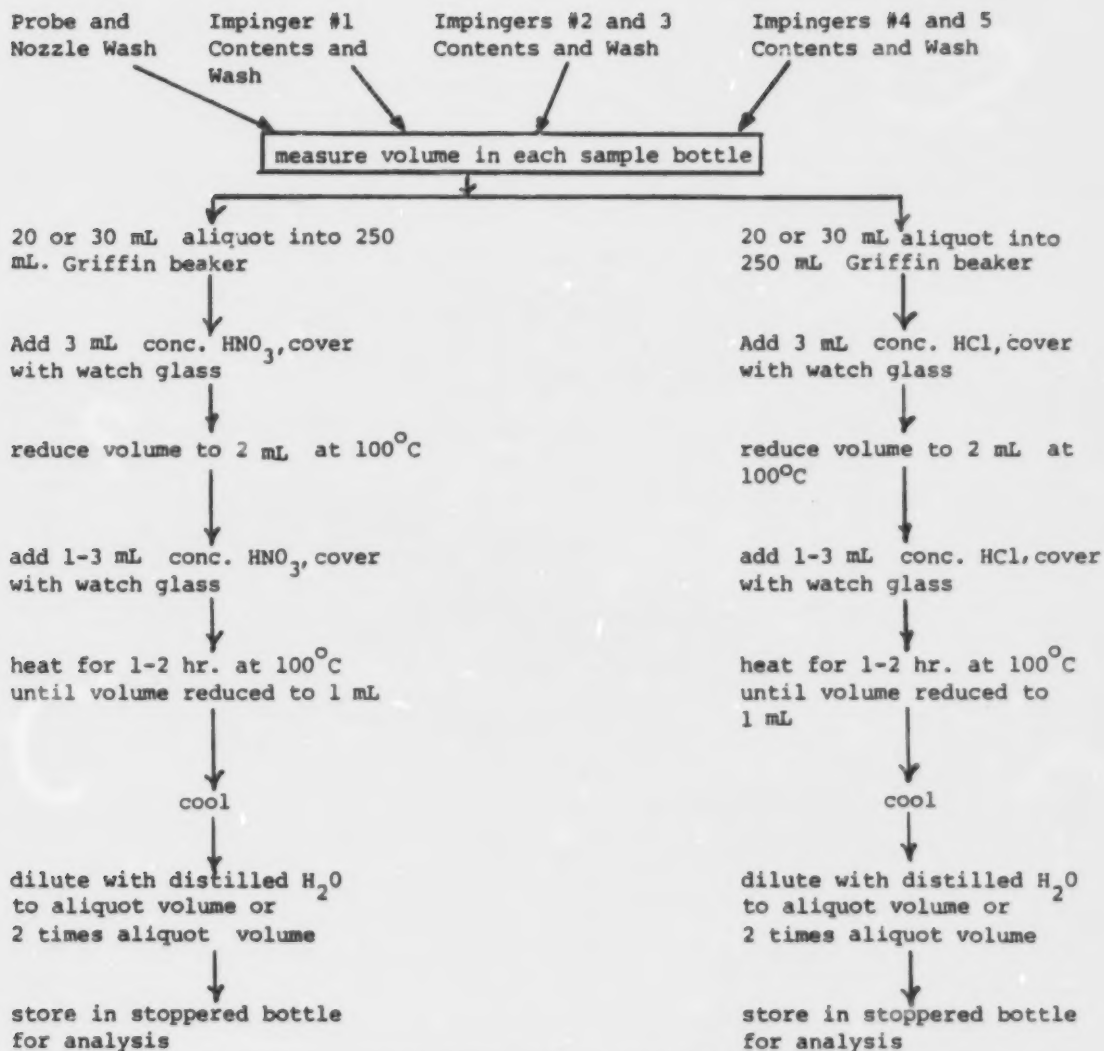
| Element       | Analytical Wavelength | Detection Limit (mg/L) | Sensitivity (mg/L) | Flame Type | Optimum Concentration Range (mg/L) | Acid Prep        | Comments                       |
|---------------|-----------------------|------------------------|--------------------|------------|------------------------------------|------------------|--------------------------------|
| Ag Silver     | 3281                  | 0.05                   | 0.03               | A-AC       | 0.1-2.0                            | HNO <sub>3</sub> |                                |
| Al Aluminum   | 3093                  | 1.0                    | 0.4                | N-AC       | 5.0-100                            | HCl              | Add 2000 ppm K                 |
| As Arsenic    | 1937                  | 0.005                  | 0.005              | furnace    | 0.005-0.05                         | HNO <sub>3</sub> |                                |
| B Boron       | 2497                  | 10                     | 9                  | N-AC       | 50-500                             | HNO <sub>3</sub> |                                |
| Be Beryllium  | 2349                  | 0.02                   | 0.01               | N-AC       | 0.1-2.0                            | HCl              | Add 5% 8-hydroxy-quinoline     |
| Cd Cadmium    | 2288                  | 0.02                   | 0.01               | A-AC       | 0.1-2.0                            | HNO <sub>3</sub> |                                |
| Co Cobalt     | 2407                  | 0.2                    | 0.05               | A-AC       | 0.5-10                             | HCl              |                                |
| Cu Copper     | 3247                  | 0.1                    | 0.03               | A-AC       | 0.5-10                             | HNO <sub>3</sub> |                                |
| Cr Chromium   | 3579                  | 0.2                    | 0.06               | N-AC       | 0.5-10                             | HNO <sub>3</sub> |                                |
| Fe Iron       | 2483                  | 0.1                    | 0.04               | A-AC       | 0.5-10                             | HNO <sub>3</sub> |                                |
| Ga Gallium    | 2874                  | 2.0                    | 1.5                | N-AC       | 5-100                              | HNO <sub>3</sub> | Add 2000 ppm K                 |
| Ge Germanium  | 2651                  | 2.0                    | 1.0                | N-AC       | 5-100                              | HNO <sub>3</sub> |                                |
| Hg Mercury    | 2537                  | 0.01                   | 0.01               | Cold vapor | 0.01-0.1                           | Special prep     |                                |
| In Indium     | 3040                  | 1.0                    | 0.2                | N-AC       | 5.0-100                            | HNO <sub>3</sub> | Add 2000 ppm K                 |
| Li Lithium    | 6708                  | 0.05                   | 0.02               | N-AC       | 0.1-2.0                            | HCl              | Add 2000 ppm K                 |
| Mn Manganese  | 2795                  | 0.05                   | 0.02               | A-AC       | 0.1-2.0                            | HNO <sub>3</sub> |                                |
| Mo Molybdenum | 3133                  | 0.5                    | 0.2                | N-AC       | 1.0-20                             | HNO <sub>3</sub> | Add 1000 ppm Al                |
| Ni Nickel     | 2320                  | 0.2                    | 0.06               | A-AC       | 0.5-10                             | HNO <sub>3</sub> |                                |
| Pb Lead       | 2170                  | 0.2                    | 0.1                | A-AC       | 0.5-10                             | HNO <sub>3</sub> |                                |
| Sb Antimony   | 2176                  | 0.4                    | 0.2                | A-AC       | 1.0-20                             | HCl              |                                |
| Sc Scandium   | 3912                  | 0.5                    | 0.1                | N-AC       | 2.0-50                             | HCl              | Add 2000 ppm K                 |
| Se Selenium   | 1960                  | 0.01                   | 0.01               | Furnace    | 0.01-0.05                          | HNO <sub>3</sub> |                                |
| Sn Tin        | 2355                  | 1.0                    | 1.0                | N-AC       | 5.0-100                            | HCl              |                                |
| Sr Strontium  | 4607                  | 0.05                   | 0.1                | N-AC       | 0.1-2.0                            | HNO <sub>3</sub> | Run by emission add 2000 ppm K |
| Te Tellurium  | 2143                  | 0.5                    | 0.2                | A-AC       | 1.0-2.0                            | HNO <sub>3</sub> |                                |
| Ti Titanium   | 3643                  | 1.0                    | 1.0                | N-AC       | 10-200                             | HCl              | Add 2000 ppm Al                |
| Tl Thallium   | 2768                  | 0.5                    | 0.1                | A-AC       | 1.0-20                             | HNO <sub>3</sub> |                                |
| V Vanadium    | 3185                  | 0.02                   | 0.01               | Furnace    | 0.05-0.5                           | HNO <sub>3</sub> |                                |
| Zn Zinc       | 2138                  | 0.03                   | 0.01               | A-AC       | 0.1-2.0                            | HCl              |                                |

### Preliminary Test Filters



Storage Bottles Polyethylene with Polyethylene Caps

Figure 4.1 Preparation of Solutions From Preliminary Test Filter Catch at Ram River Gas Plant(1)  
(Preliminary Digestion Procedure)



Storage Bottles Polyethylene with Polyethylene Caps

Figure 4.2 Preparation of Solutions From Preliminary Test Liquid Catches at Ram River Gas Plant(1) (Preliminary Digestion Procedure)

The preparations of filter and solution blanks are illustrated in Figure 4.3 and Figure 4.4, respectively.(1)

Because the preliminary procedures failed to detect the presence of any of the 29 metal species, it became necessary to achieve as much concentration as possible before submitting the final samples to the atomic absorption techniques.

#### B. PLANT TESTS

As shown in Figure 4.5 the filters from all final tests were cut into halves to provide more concentrated  $\text{HNO}_3$  and  $\text{HCl}$  solutions of the metals under investigation.

All test liquid catches were treated according to the flowsheet illustrated in Figure 4.6. Impingers 1, 2 and 3 were combined and the total volume was reduced to 25 mL by evaporation. Similarly the combined volume of impingers 4 and 5 was reduced to 25 mL by evaporation. The contents of impingers 4 and 5 were reduced to 25 mL independently for the Quirk Creek sampling program.

The preparation of filter and solution blanks is illustrated in Figure 4.7. Because of the potential for interferences and matrix effects to be created as a result of the complexity of the solutions being analyzed, it was essential to determine the recovery of each metal species by creating synthetic systems of known composition of each of the 29 elements under investigation. Clean filters and distilled water samples were spiked with appropriate volumes of the 1000 ppm AA standards

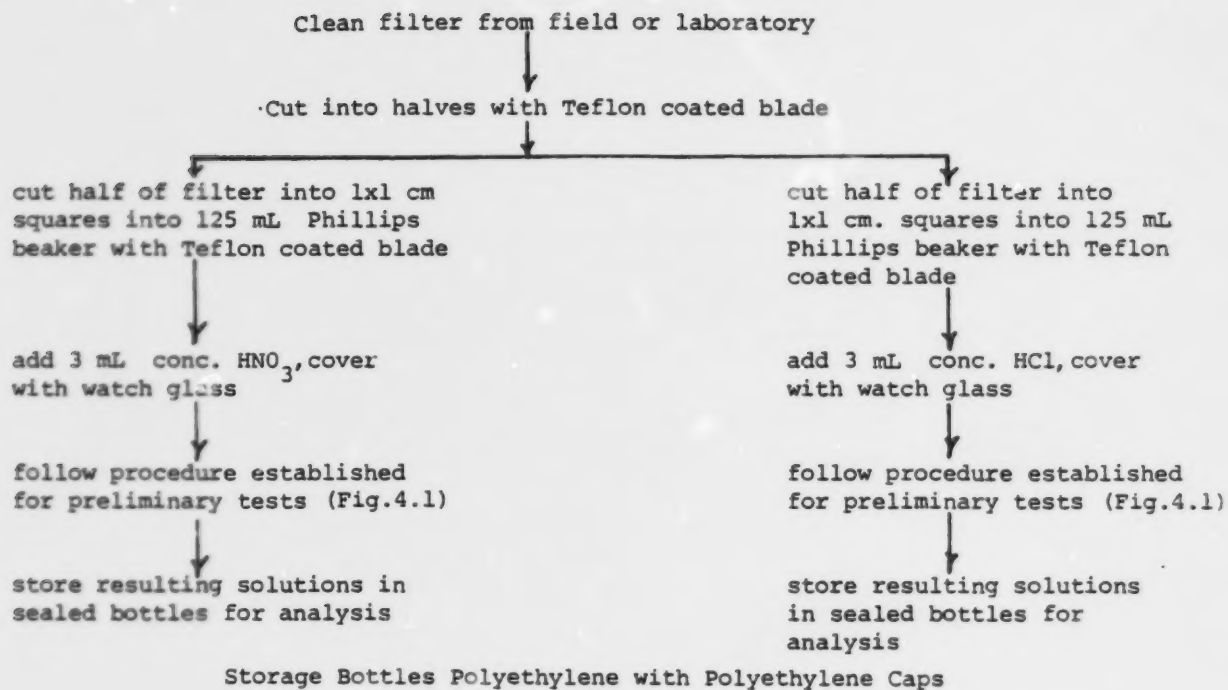
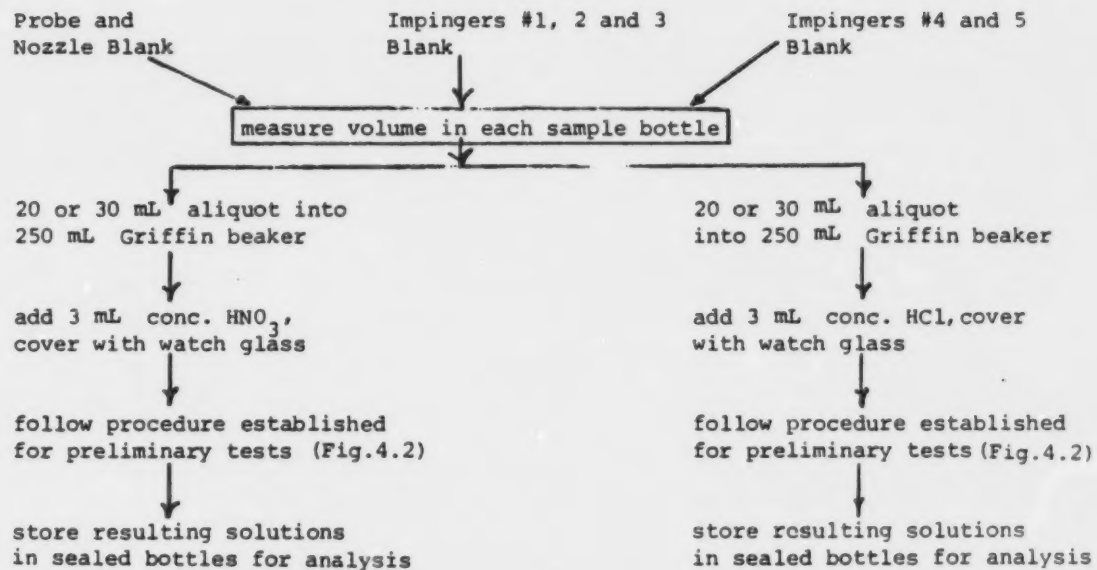


Figure 4.3 Steps Involved in the Preparation of Field and Laboratory Filter Blanks for Preliminary Tests.(1)



Storage Bottles Polyethylene with Polyethylene Caps

Figure 4.4 Steps Involved in the Preparation of Solution Blanks.(1)  
(Preliminary Digestion Procedure)

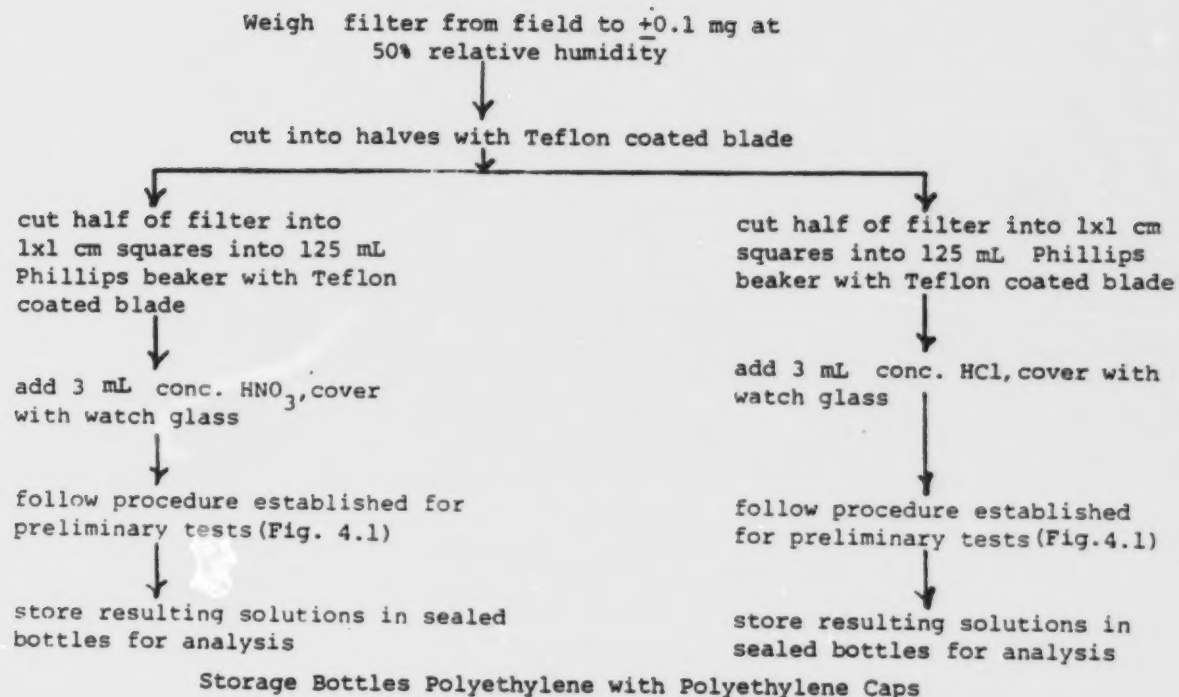
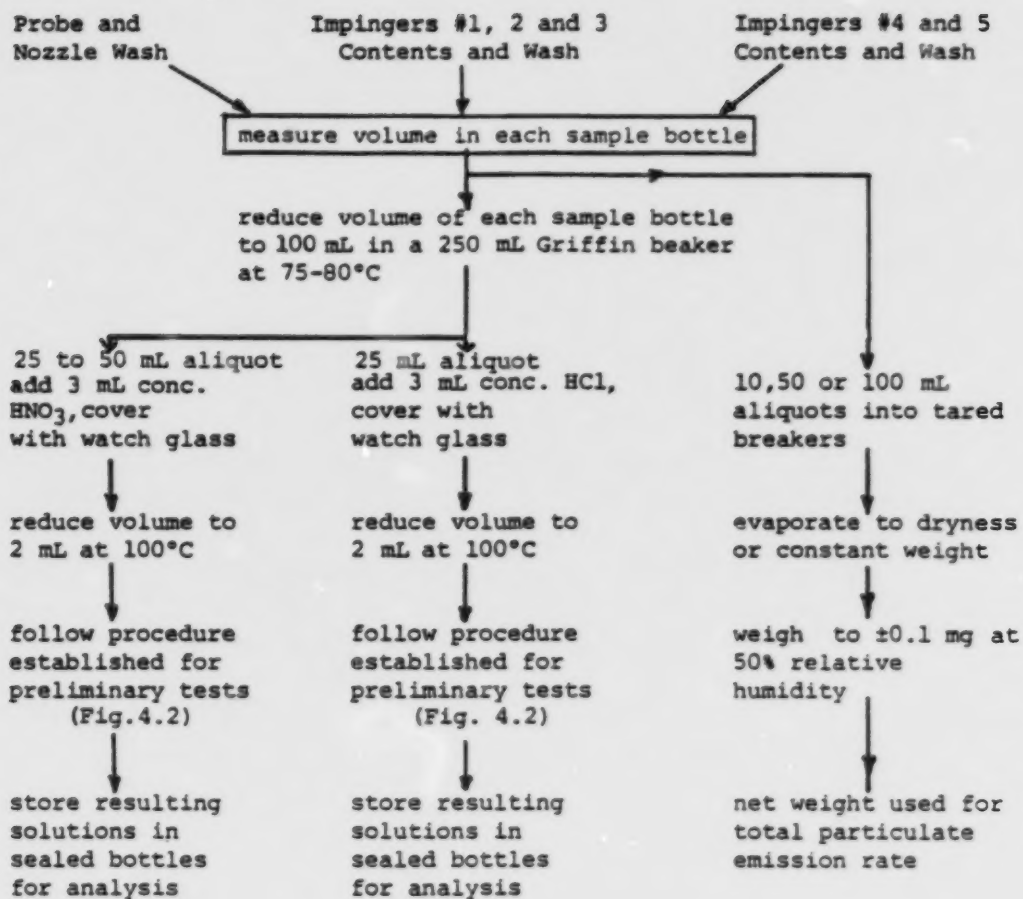


Figure 4.5: Treatment of Filters From Final Tests.





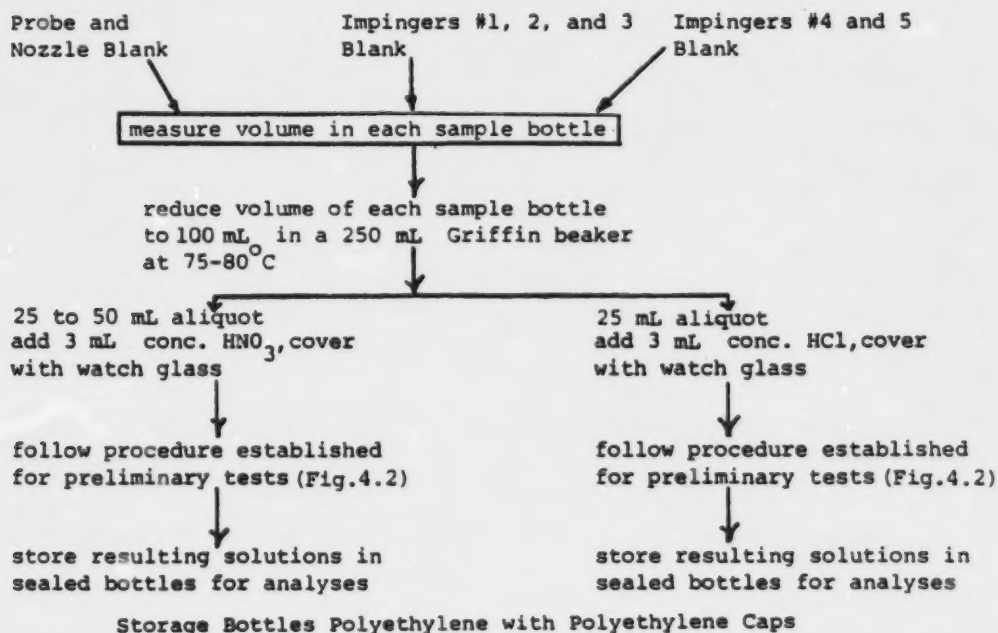
Storage Bottles Polyethylene with Polyethylene Caps

Figure 4.6: Treatment of Solutions From Final Tests

### Filter Analyses

Follow procedures established for field and laboratory blanks on filters used for preliminary survey

### Solution Analyses



Storage Bottles Polyethylene with Polyethylene Caps

Figure 4.7: Preparation of Blanks for Filter and Solution Analyses

according to the schemes illustrated in Table 4.2 and Table 4.3, respectively. The preparations of solutions for the filter and liquid recoveries are illustrated in Figures 4.8 and Figure 4.9, respectively.

### C. ATOMIC ABSORPTION SPECTROMETRY

Atomic absorption analyses were carried out with an Instrumentation Laboratory Model IL 551 Video I double beam atomic absorption/atomic emission spectrophotometer with microcomputer, cathode-ray tube display. Flameless analyses were performed using a Varian Model 975 spectrophotometer equipped with a Varian temperature controlled furnace Model GTA95. The instruments were equipped to use air/acetylene, nitrous oxide/acetylene, or argon/hydrogen flames depending on the element being investigated. Table 4.1 summarizes the flame types for each element.

Limits of detection of each metal in mg/L were established by analyzing the lowest standard 10 times in order to determine the mean value of the absorbance and the standard deviation in terms of absorbance. Each detection limit shown in Table 4.1 was evaluated according to the expression:

|                              |       |                                                                                   |                                    |
|------------------------------|-------|-----------------------------------------------------------------------------------|------------------------------------|
| Detection<br>Limit<br>(mg/L) | = 2 x | standard<br>deviation (absorbance units)<br>mean of<br>10 runs (absorbance units) | x standard<br>concentration (mg/L) |
|------------------------------|-------|-----------------------------------------------------------------------------------|------------------------------------|

Table 4.2 Amounts of Standards Added to Filters  
for Recoveries Using 1000 ppm Standards

| HNO <sub>3</sub> TREATMENT |                    | HCl TREATMENT |                    |
|----------------------------|--------------------|---------------|--------------------|
| Element                    | Amount Added<br>uL | Element       | Amount Added<br>uL |
| Mn                         | 25                 | Ti            | 2000               |
| Ni                         | 100                | Co            | 100                |
| Cu                         | 100                | Zn            | 25                 |
| Ga                         | 1000               | Sb            | 200                |
| Ge                         | 1000               | Be            | 25                 |
| Mo                         | 200                | Al            | 1000               |
| Pb                         | 100                | Sn            | 1000               |
| Sr                         | 50                 | Li            | 25                 |
| B                          | 3000               | Sc            | 200                |
| Ag                         | 25                 |               |                    |
| Tl                         | 200                |               |                    |
| In                         | 1000               |               |                    |
| Te                         | 500                |               |                    |
| Fe                         | 100                |               |                    |
| As                         | 1                  |               |                    |
| Se                         | 1                  |               |                    |
| V                          | 10                 |               |                    |
| Hg                         | 50                 |               |                    |
| Cd                         | 25                 |               |                    |
| Cr                         | 100                |               |                    |

Table 4.3 Amounts of Standards Added to Solutions  
for Recoveries Using 1000 ppm Standards

| HNO <sub>3</sub> TREATMENT |                                  | HCl TREATMENT  |                                  |
|----------------------------|----------------------------------|----------------|----------------------------------|
| <u>Element</u>             | <u>Amount Added</u><br><u>uL</u> | <u>Element</u> | <u>Amount Added</u><br><u>uL</u> |
| Mn                         | 25                               | Ti             | 1000                             |
| Ni                         | 250                              | Co             | 100                              |
| Cu                         | 250                              | Zn             | 25                               |
| Ga                         | 1000                             | Sb             | 200                              |
| Ge                         | 1000                             | Be             | 25                               |
| Mo                         | 100                              | Al             | 1000                             |
| Cd                         | 25                               | Sn             | 500                              |
| Pb                         | 250                              | Li             | 25                               |
| Sr                         | 50                               | Sc             | 200                              |
| B                          | 6000                             |                |                                  |
| Ag                         | 25                               |                |                                  |
| Tl                         | 500                              |                |                                  |
| In                         | 3000                             |                |                                  |
| Te                         | 500                              |                |                                  |
| Fe                         | 250                              |                |                                  |
| As                         | 5                                |                |                                  |
| Se                         | 5                                |                |                                  |
| V                          | 10                               |                |                                  |
| Hg                         | 10                               |                |                                  |
| Cr                         | 100                              |                |                                  |

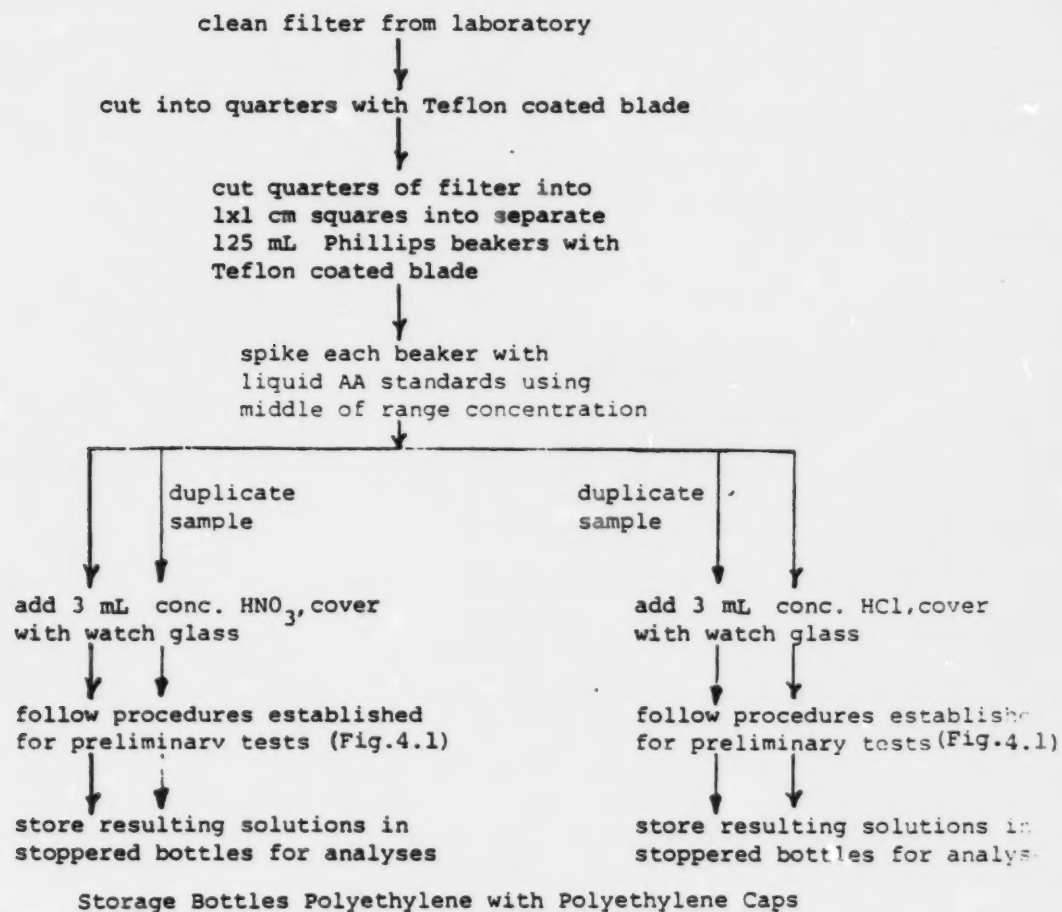


Figure 4.8: Preparation of Solutions for Component Recoveries From Filters

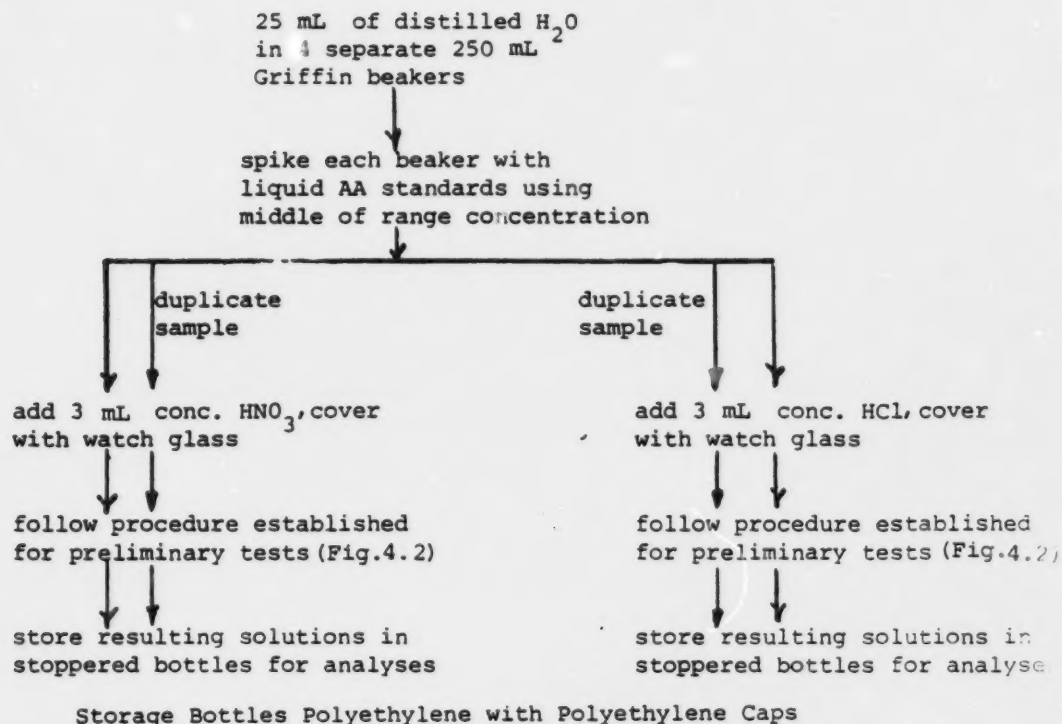


Figure 4.9: Preparation of Solutions for Component Recoveries From Solutions



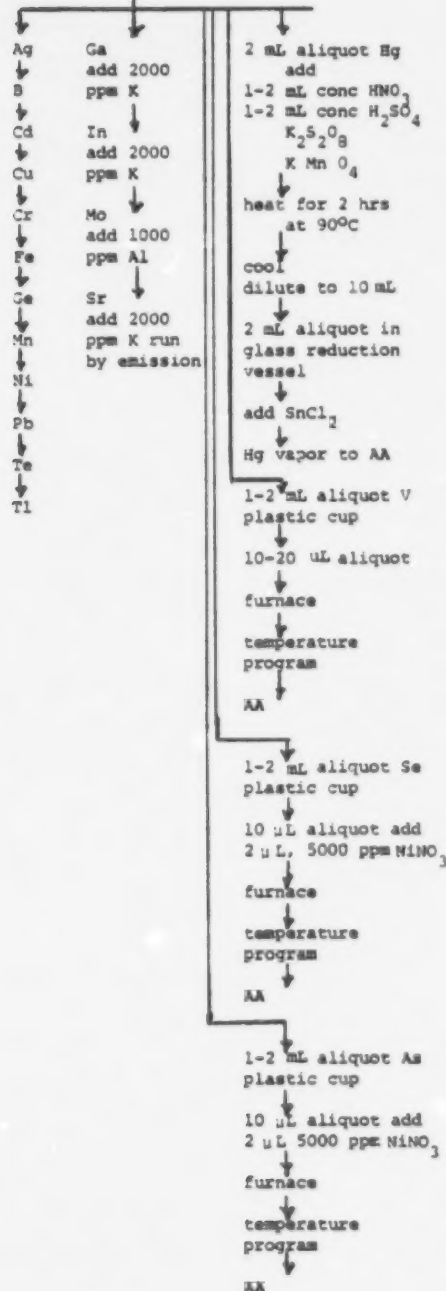
Calibration curves were prepared by running all standards except the lowest ones twice each. Analyses of samples, blanks and recoveries were followed by running of the standards twice if less than 10 samples were being handled. Standards were checked every 10 samples when large numbers of samples were being processed.

Figure 4.10 illustrates the procedures adopted for atomic absorption spectrometric determination of the trace metals under consideration.

HNO<sub>3</sub> solutions in stoppered bottles containing:

Ag; As; B; Cd; Cu; Cr; Fe;  
Ga; Ge; Hg; In; Mn; Mo; Ni;  
Pb; Se; Sr; Te; Tl; V

separate aliquots to atomic absorption spectrometer



HCl solutions in stoppered bottles containing:

Al; Be; Co; Li; Sb; Se; Sn; Ti;  
Zn

separate aliquots to atomic absorption spectrometer

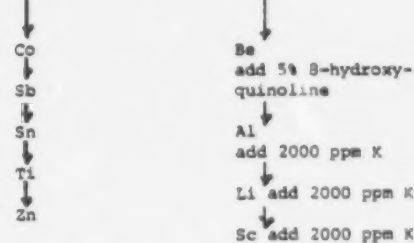


Figure 4.10 Treatment of HNO<sub>3</sub> and HCl Solutions for Atomic Absorption Spectrometry

## V. RESULTS

Comprehensive pre-sampling investigations indicated that meaningful results could only be obtained with pre-concentration of field blanks and liquids recovered from impingers and traps.

### A. PRELIMINARY FIELD TESTING

The analytical procedures were finalized following field experiences associated with the preliminary test at the Ram River Gas Plant.(1)

### B. PLANT TESTS

Four particulate matter sampling tests (1 preliminary and 3 official) were conducted at the following locations:

- Canadian Superior Oil Ltd. - Harmattan Gas Plant  
between 23-26 June, 1983
- Gulf Oil Canada Ltd. - Nevis Gas Plant between  
27-30 June, 1983
- Petro Canada - Gold Creek Gas Plant between  
2-5 July, 1983
- Canterra Energy Limited - Rainbow Lake Gas Plant  
between 7-10 July, 1983
- Esso Resources Canada Ltd. - Quirk Creek Gas Plant  
between 22-25 November, 1983.

All sample acquisition was carried out with borosilicate glass lined probes.

Appendix III details the field data, isokineticity checks, individual metal concentrations and emission rates for the 15 tests for which sample integrity was maintained during shipment.

Appendix IV provides the sour gas plant operating data collected during the actual testing periods by ERCB personnel.

Tables 5.1 and 5.2 summarize the laboratory recoveries of the 29 metals from spiked filter and liquid samples.

The trace element emission rates of metals, whose presence was "detected", are summarized in Figures 5.1 to 5.5. These values were determined employing the measured elemental concentrations and values corresponding to the limits of detection (LOD) for the four samples recovered from the sampling train for each test. Consequently, the mean emission rates corresponding to the full circles represent maximum possible values. The upper and lower bounds indicate the range of emission rates for each plant tested. Open circles indicate the average of the maximum emission rates which correspond to the use of LOD values only.

Discussions following the 66th Canadian Chemical Conference(21) and peer reviews(22-25) indicated the necessity for carefully defining criteria used to "establish" the presence of any metal in the incinerator stack gases at significant levels because of the sporadic appearances and low concentrations associated with the elements.

Table 5.1 Per Cent Recoveries of Metals From Spiked Filters

|    |            | 4/10-25/10<br>Gold Creek-Rainbow |      | 1983<br>Lake Ave | 2/1-12/1<br>Quirk Creek |     | 1984<br>Ave  |
|----|------------|----------------------------------|------|------------------|-------------------------|-----|--------------|
|    |            | #1                               | #2   |                  | #1                      | #2  |              |
| Ag | Silver     | 85                               | 90   | 88 $\pm$ 4       | 85                      | 85  | 85 $\pm$ 0   |
| Al | Aluminum   | 90                               | 83   | 87 $\pm$ 5       | 90                      | 90  | 90 $\pm$ 0   |
| As | Arsenic    | n.s.                             | n.s. | n.s.             | 130                     | 113 | 122 $\pm$ 12 |
| B  | Boron      | 105                              | 102  | 104 $\pm$ 2      | 103                     | 107 | 105 $\pm$ 3  |
| Be | Beryllium  | 101                              | 105  | 103 $\pm$ 3      | 91                      | 93  | 92 $\pm$ 1   |
| Cd | Cadmium    | 90                               | 92   | 91 $\pm$ 1       | 92                      | 100 | 96 $\pm$ 6   |
| Co | Cobalt     | 73                               | 73   | 73 $\pm$ 0       | 90                      | 95  | 93 $\pm$ 4   |
| Cr | Chromium   | 100                              | 95   | 98 $\pm$ 4       | 100                     | 110 | 105 $\pm$ 7  |
| Cu | Copper     | 100                              | 100  | 100 $\pm$ 0      | 90                      | 90  | 90 $\pm$ 0   |
| Fe | Iron       | 105                              | 105  | 105 $\pm$ 0      | 90                      | 100 | 95 $\pm$ 7   |
| Ga | Gallium    | 105                              | 105  | 105 $\pm$ 0      | 85                      | 84  | 85 $\pm$ 1   |
| Ge | Germanium  | 95                               | 95   | 95 $\pm$ 0       | 80                      | 70  | 75 $\pm$ 7   |
| Hg | Mercury    | n.s.                             | n.s. | n.s.             | 89                      | 85  | 87 $\pm$ 3   |
| In | Indium     | 95                               | 95   | 95 $\pm$ 0       | 82                      | 89  | 86 $\pm$ 5   |
| Li | Lithium    | 95                               | 98   | 97 $\pm$ 2       | 100                     | 103 | 102 $\pm$ 2  |
| Mn | Manganese  | 104                              | 104  | 104 $\pm$ 0      | 76                      | 92  | 84 $\pm$ 11  |
| Mo | Molybdenum | n.s.                             | n.s. | n.s.             | 100                     | 98  | 99 $\pm$ 1   |
| Ni | Nickel     | 101                              | 99   | 100 $\pm$ 1      | 90                      | 90  | 90 $\pm$ 0   |
| Pb | Lead       | 95                               | 95   | 95 $\pm$ 0       | 95                      | 105 | 100 $\pm$ 7  |
| Sb | Antimony   | 96                               | 101  | 99 $\pm$ 4       | 88                      | 88  | 88 $\pm$ 0   |
| Sc | Scandium   | 75                               | 65   | 70 $\pm$ 7       | 79                      | 85  | 82 $\pm$ 4   |
| Se | Selenium   | n.s.                             | n.s. | n.s.             | 105                     | 95  | 100 $\pm$ 7  |
| Sn | Tin        | 85                               | 85   | 85 $\pm$ 0       | 98                      | 100 | 99 $\pm$ 1   |
| Sr | Strontium  | 92                               | 96   | 94 $\pm$ 3       | 84                      | 90  | 87 $\pm$ 4   |
| Te | Tellurium  | 92                               | 89   | 91 $\pm$ 2       | 92                      | 98  | 95 $\pm$ 4   |
| Ti | Titanium   | 65                               | 69   | 67 $\pm$ 3       | 49                      | 48  | 49 $\pm$ 1   |
| Tl | Thallium   | n.s.                             | n.s. | n.s.             | 93                      | 100 | 97 $\pm$ 5   |
| V  | Vanadium   | n.s.                             | n.s. | n.s.             | 100                     | 105 | 103 $\pm$ 4  |
| Zn | Zinc       | 86                               | 96   | 91 $\pm$ 7       | 88                      | 85  | 87 $\pm$ 2   |

n.s. - not spiked

Table 5.2 Per Cent Recoveries of Metals From Spiked Liquids

|    |            | 18/8-1/9       |          | 1983   | 14/11-29/11   |                 | 1983   | 2/1-12/1       |      | 1984   |
|----|------------|----------------|----------|--------|---------------|-----------------|--------|----------------|------|--------|
|    |            | Harmattan - #1 | Nevis #2 | Ave    | Gold Creek #1 | Rainbow Lake #2 | Ave    | Quirk Creek #1 | #2   | Ave    |
| Ag | Silver     | 4*             | 12*      | 8+ 6   | 105           | 105             | 105+ 0 | 70             | 55   | 63+11  |
| Al | Aluminum   | 93             | 90       | 92+ 2  | 113           | 110             | 112+ 2 | 100            | 103  | 102+ 2 |
| As | Arsenic    | 90             | 100      | 95+ 7  | 95            | 103             | 99+ 6  | 133            | 130  | 132+ 2 |
| B  | Boron      | 162            | 162      | 162+ 0 | 139           | 136             | 138+ 2 | 107            | 107  | 107+ 0 |
| Be | Beryllium  | 92             | 88       | 90+ 3  | 106           | 107             | 107+ 1 | 95             | 96   | 96+ 1  |
| Cd | Cadmium    | 96             | 96       | 96+ 0  | 100           | 100             | 100+ 0 | 98             | 108  | 103+ 7 |
| Co | Cobalt     | 100            | 98       | 99+ 1  | 108           | 105             | 107+ 2 | 45             | 48   | 47+ 2  |
| Cr | Chromium   | 100            | 95       | 98+ 4  | 105           | 115             | 110+ 7 | 100            | 105  | 103+ 4 |
| Cu | Copper     | 100            | 105      | 103+ 4 | 105           | 105             | 105+ 0 | 105            | 105  | 105+ 0 |
| Fe | Iron       | n.s.           | 100      | 100    | 100           | 100             | 100+ 0 | 100            | 100  | 100+ 0 |
| Ga | Gallium    | 105            | 105      | 105+ 0 | 95            | 100             | 98+ 4  | 106            | 107  | 107+ 1 |
| Ge | Germanium  | 47             | 55       | 51+ 6  | 110           | 115             | 113+ 4 | 90             | 90   | 90+ 0  |
| Hg | Mercury    | 110            | 102      | 106+ 6 | 100           | 102             | 101+ 1 | 84             | 87   | 86+ 2  |
| In | Indium     | 95             | 95       | 95+ 0  | 105           | 110             | 108+ 4 | 101            | 103  | 102+ 1 |
| Li | Lithium    | 120            | 120      | 102+ 0 | 100           | 96              | 98+ 3  | 115            | n.s. | 115    |
| Mn | Manganese  | 124            | 116      | 120+ 6 | n.s.          | n.s.            | n.s.   | 108            | 100  | 104+ 6 |
| Mo | Molybdenum | 90             | 90       | 90+ 0  | 168           | 173             | 171+ 4 | 100            | 97   | 99+ 2  |
| Ni | Nickel     | 100            | 100      | 100+ 0 | 105           | 105             | 105+ 0 | 100            | 100  | 100+ 0 |
| Pb | Lead       | 100            | 100      | 100+ 0 | 100           | 105             | 103+ 4 | 110            | 95   | 103+10 |
| Sb | Antimony   | 100            | 99       | 100+ 1 | 111           | 116             | 114+ 4 | 88             | 88   | 88+ 0  |
| Sc | Scandium   | 92             | 92       | 92+ 0  | 125           | 123             | 124+ 1 | 63             | 91   | 77+20  |
| Se | Selenium   | 90             | 65       | 78+18  | 93            | 103             | 98+ 7  | 113            | 110  | 112+ 2 |
| Sn | Tin        | 108            | 105      | 107+ 2 | 108           | 75              | 92+23  | 105            | 100  | 103+ 4 |
| Sr | Strontium  | 100            | 110      | 105+ 7 | 100           | 110             | 105+ 7 | 102            | 97   | 100+ 4 |
| Te | Tellurium  | 95             | 93       | 94+ 1  | 110           | 110             | 110+ 0 | 103            | 103  | 103+ 0 |
| Ti | Titanium   | 98             | 95       | 97+ 2  | 53            | 53              | 53+ 0  | 45             | 44   | 45+ 1  |
| Tl | Thallium   | 100            | 105      | 103+ 3 | 110           | 110             | 110+ 0 | 100            | 100  | 100+ 0 |
| V  | Vanadium   | 120            | 110      | 115+ 7 | 105           | 105             | 105+ 0 | 115            | 110  | 113+ 4 |
| Zn | Zinc       | 99             | 89       | 94+ 7  | 119           | 115             | 117+ 3 | 99             | 98   | 99+ 1  |

n.s. - not spiked

\* - possibly bad standard





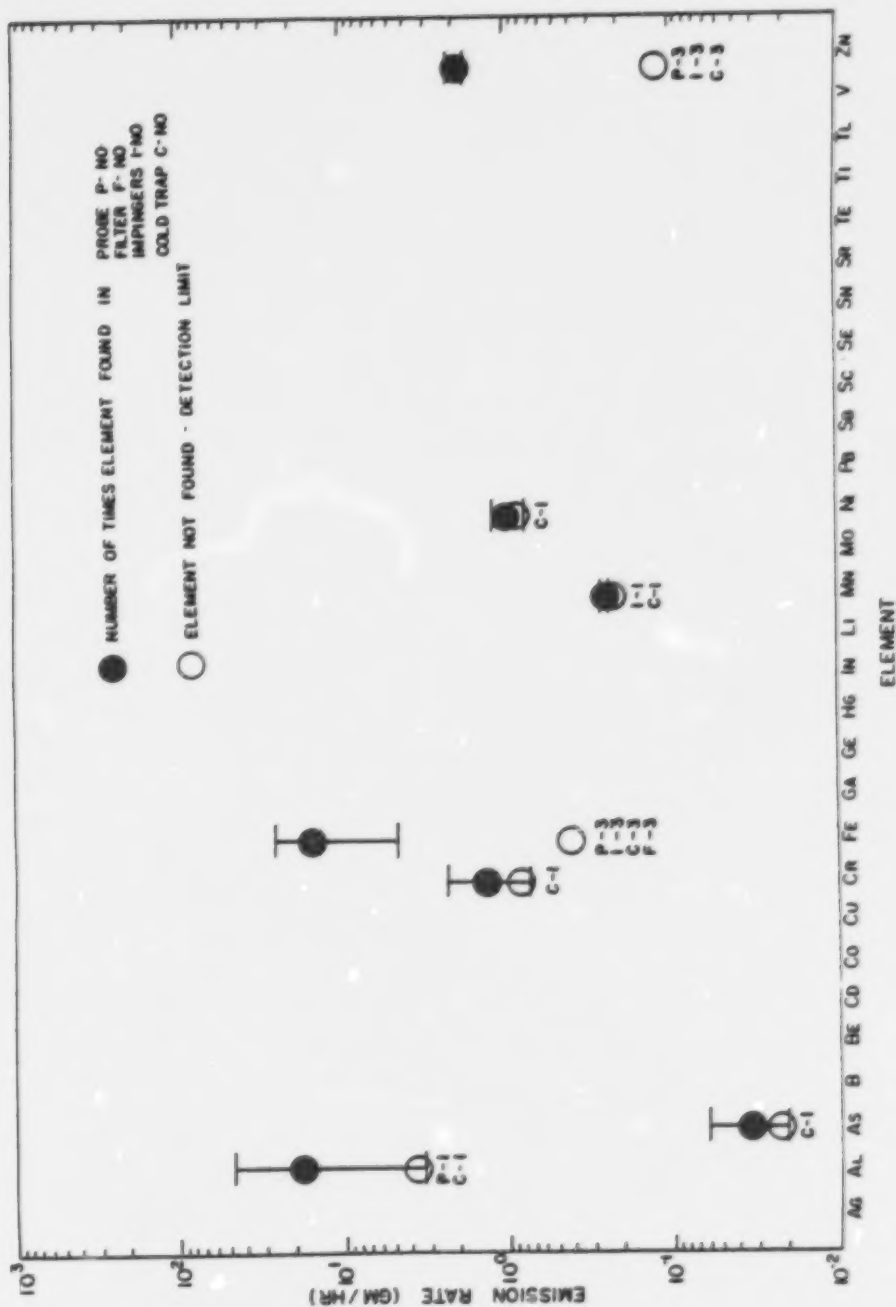


Figure 5.2: Maximum Emission Rates of Metals Whose Presence was "Detected" in Gulf-Nevils Incinerator Stack Gases Using a Borosilicate Glass Liner.

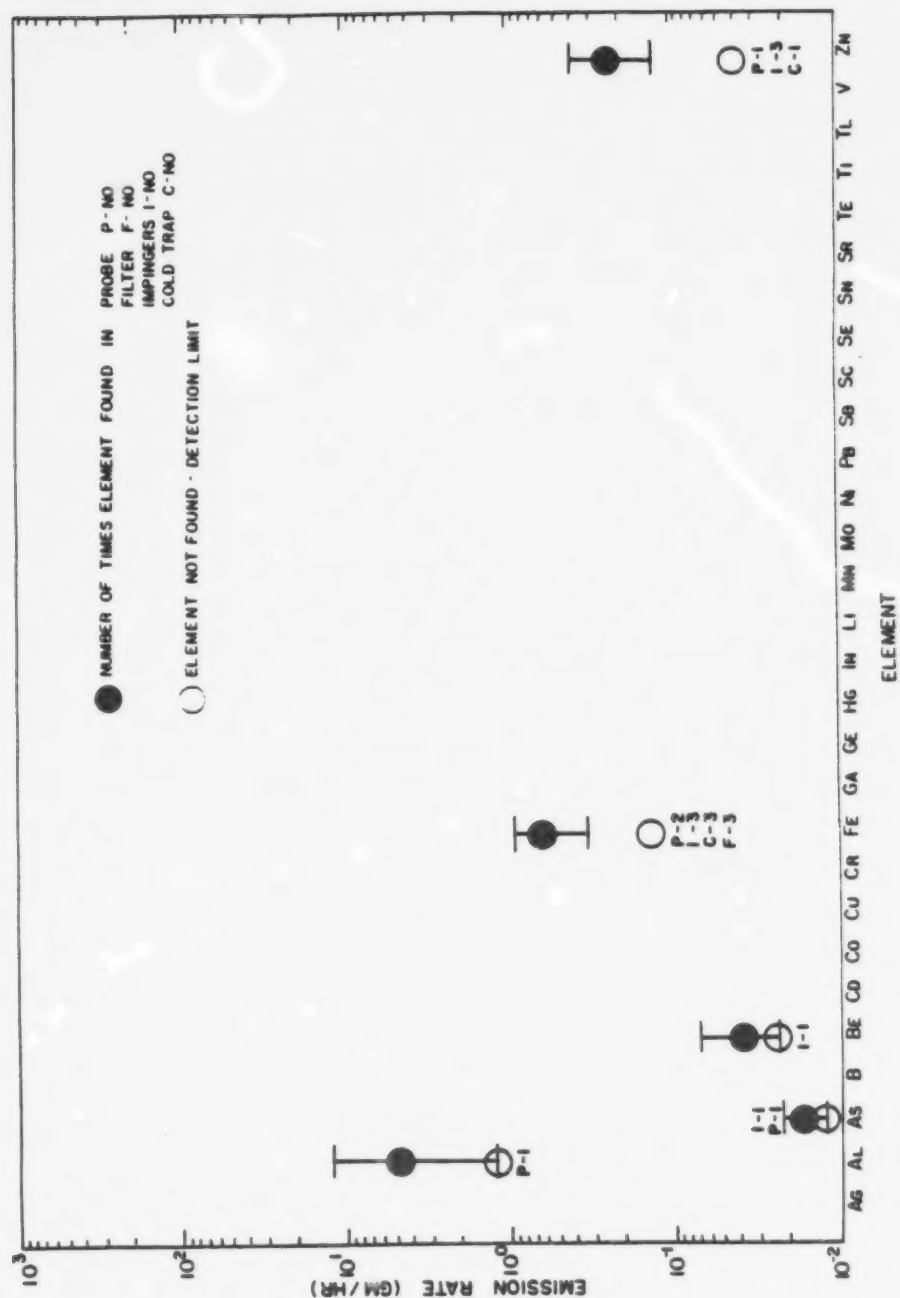


Figure 5.3: Maximum Emission Rates of Metals Whose Presence was "Detected" in Petro Canada-Gold Creek Incinerator Stack Gases Using a Borosilicate Glass Liner.

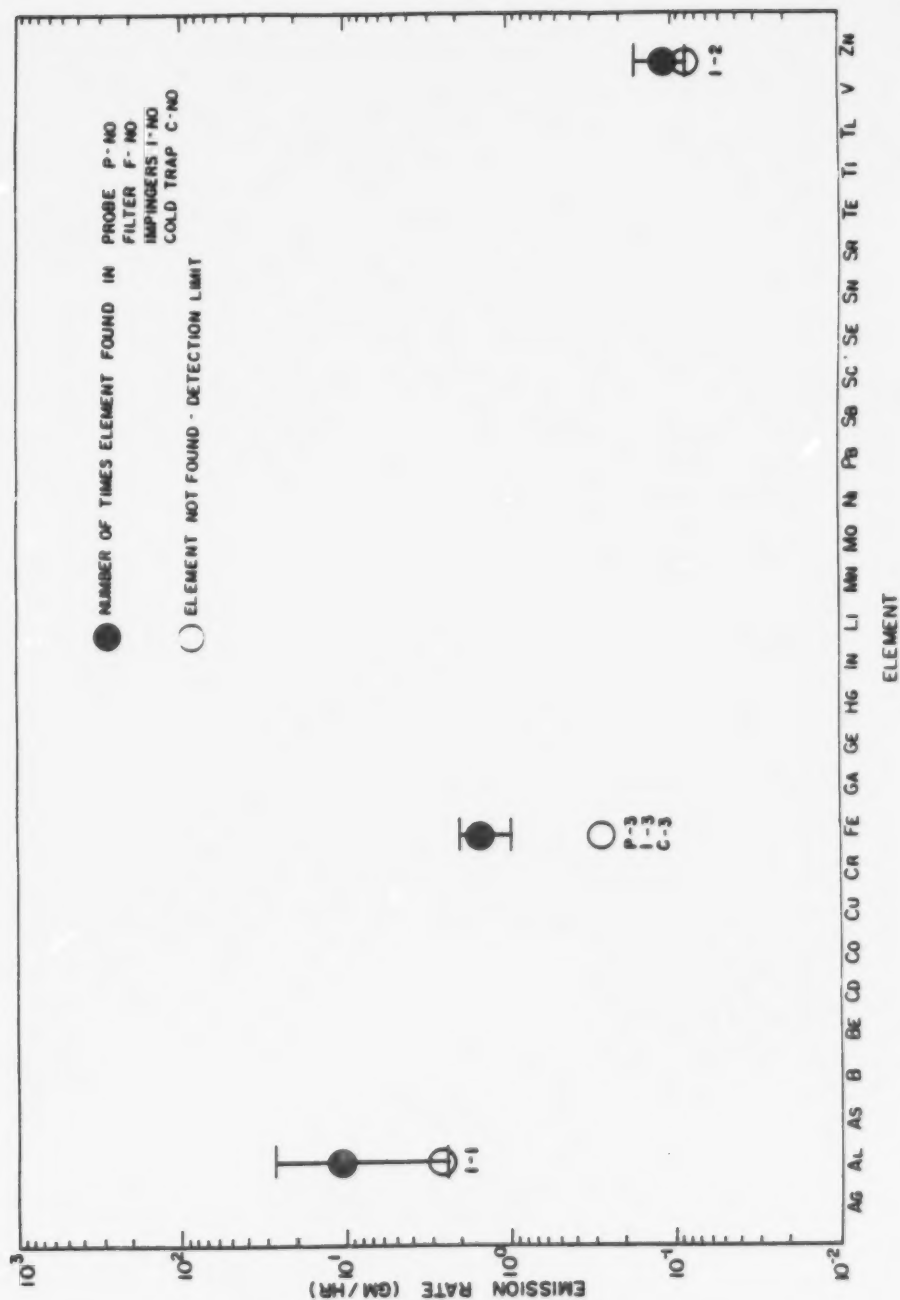


Figure 5.4: Maximum Emission Rates of Metals Whose Presence was "Detected" in Canterra-Rainbow Lake Incinerator Stack Gases Using a Borosilicate Glass Liner.

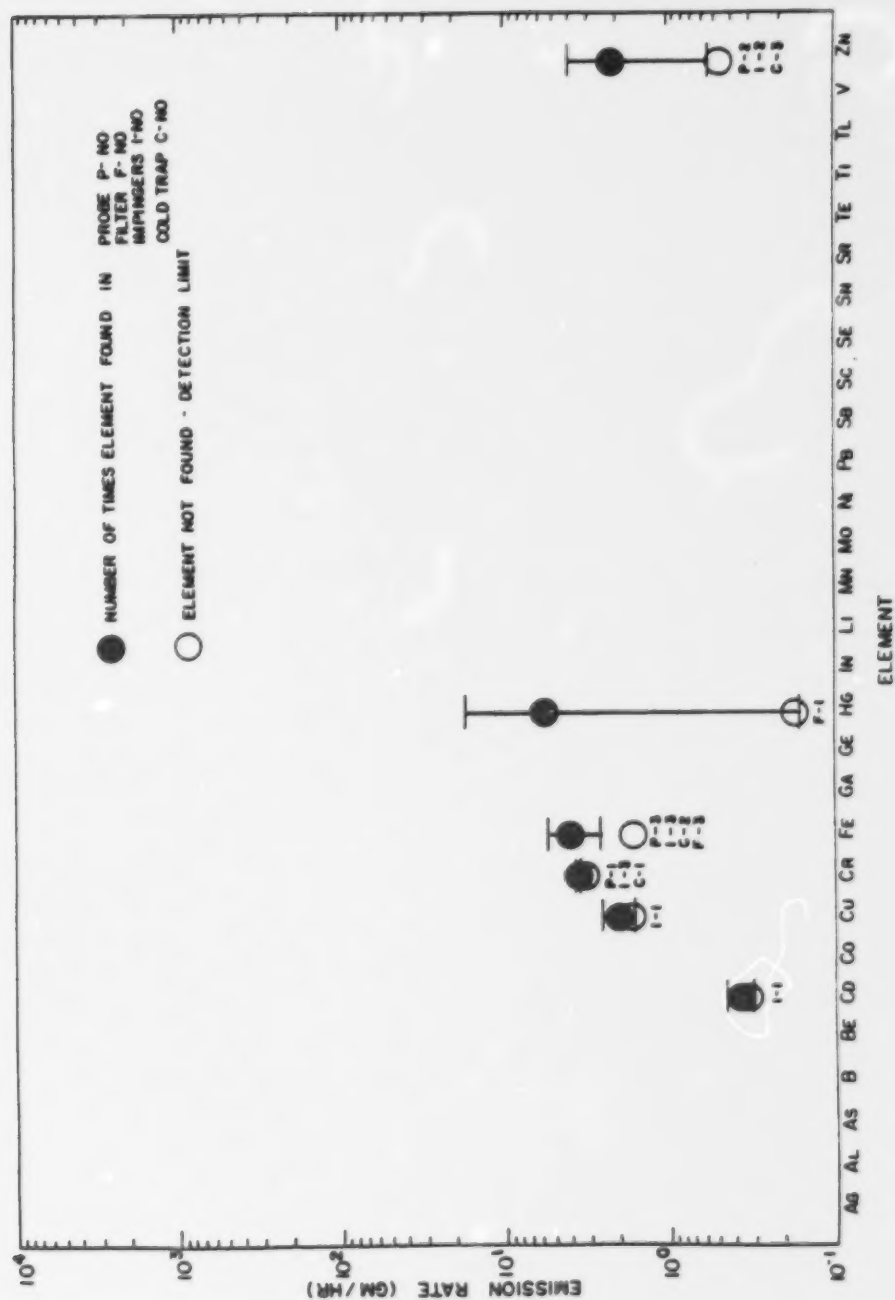


Figure 5.5: Maximum Emission Rates of Metals Whose Presence was "Detected" in Esso-Quirk Creek Incinerator Stack Gases Using a Borosilicate Glass Liner.

A metal is reported as being present in significant amounts if the element was "detected"

- in more than one-half of the tests or
- at a concentration 3 times the limit of detection (LOD).

Table 5.3 summarizes the plant emission rates using these criteria.

Appendix V details the maximum possible incinerator stack emission rates that could exist without detection of any metallic species employing the sample recovery and analytical procedures developed for this investigation. The effects of preconcentration, total gas sample volume collected and instrumental limits of detection on the maximum possible rates are discussed in detail.

Table 5.3: Summary of Emission Rates of Elements Whose Presence was Established at Canadian Superior-Harmattan, Gulf-Nevis, Petro Canada-Gold Creek, Canterra-Rainbow Lake and Esso-Quirk Creek Gas Plants Using Borosilicate Glass Lined Probes.

| Plant Test #                | Date D/M/Y | Liner | Plant Production 10 <sup>6</sup> m <sup>3</sup> /d | Average Stack Temperature T <sub>s</sub> (°F) | Average Moisture by Condensation % <sub>mo</sub> | Average Stack Velocity V <sub>s</sub> ft/s | Average Volumetric Flow Rate Q <sub>v</sub> acfm | Average SO <sub>2</sub> Concentration % by Volume | Metal Species Emission Rate g/h |      |      |     |     |     |     |     |      |     |      |     | Emission Rate |                                |                            |      |
|-----------------------------|------------|-------|----------------------------------------------------|-----------------------------------------------|--------------------------------------------------|--------------------------------------------|--------------------------------------------------|---------------------------------------------------|---------------------------------|------|------|-----|-----|-----|-----|-----|------|-----|------|-----|---------------|--------------------------------|----------------------------|------|
|                             |            |       |                                                    |                                               |                                                  |                                            |                                                  |                                                   | Al                              | As   | Ba   | Cd  | Cr  | Cu  | Fe  | Hg  | Mn   | Mo  | Ni   | Sr  | Zn            | Front End 10 <sup>4</sup> kg/d | Total 10 <sup>4</sup> kg/d |      |
| Canadian Superior Harmattan |            |       |                                                    |                                               |                                                  |                                            |                                                  |                                                   |                                 |      |      |     |     |     |     |     |      |     |      |     |               |                                |                            |      |
| #1                          | 24/6/83    | G     | • 3.67                                             | 1138                                          | 0.197                                            | 36.5                                       | 134268                                           | 0.65                                              | ---                             | ---  | ---  | --- | --- | --- | --- | 76  | ---  | 1.2 | ---  | 4.3 | ---           | 5.2                            | 4.5                        | 6.4  |
| #2                          | 25/6/83    | G     | • 3.75                                             | 1140                                          | 0.184                                            | 37.2                                       | 136580                                           | 0.43                                              | ---                             | ---  | ---  | --- | --- | --- | --- | 13  | 1800 | --- | 7.5  | --- | 4.3           | 430                            | 9.8                        | 4.3  |
| #3                          | 26/6/83    | G     | • 3.77                                             | 1140                                          | 0.184                                            | 37.9                                       | 139288                                           | 0.37                                              | ---                             | ---  | ---  | --- | --- | --- | --- | --- | 40   | --- | ---  | --- | 4.4           | ---                            | 5.5                        | 2.1  |
| Gulf Nevis                  |            |       |                                                    |                                               |                                                  |                                            |                                                  |                                                   |                                 |      |      |     |     |     |     |     |      |     |      |     |               |                                |                            |      |
| #1                          | 28/6/83    | G     | n.r.                                               | 925                                           | 0.168                                            | 61.8                                       | 46579                                            | 0.32                                              | 45                              | 0.06 | ---  | --- | --- | --- | --- | --- | 17   | --- | ---  | --- | ---           | 2.2                            | 1.6                        | 1.4  |
| #2                          | 29/6/83    | G     | n.r.                                               | 926                                           | 0.168                                            | 57.4                                       | 43274                                            | 0.32                                              | 4.6                             | ---  | ---  | --- | --- | --- | --- | --- | 4.6  | --- | 0.23 | --- | ---           | 1.8                            | 1.1                        | 0.64 |
| #3                          | 30/6/83    | G     | n.r.                                               | 925                                           | 0.160                                            | 56.0                                       | 42194                                            | 0.34                                              | ---                             | ---  | ---  | --- | --- | --- | --- | --- | 26   | --- | 0.25 | --- | ---           | 1.8                            | 1.5                        | 0.95 |
| Petro Canada Gold Creek     |            |       |                                                    |                                               |                                                  |                                            |                                                  |                                                   |                                 |      |      |     |     |     |     |     |      |     |      |     |               |                                |                            |      |
| #1                          | 3/7/83     | G     | n.r.                                               | 951                                           | 0.144                                            | 28.6                                       | 15948                                            | 0.21                                              | ---                             | 0.02 | 0.07 | --- | --- | --- | --- | --- | 0.63 | --- | ---  | --- | ---           | 0.13                           | 0.54                       | 0.24 |
| #2                          | 4/7/83     | G     | n.r.                                               | 951                                           | 0.165                                            | 29.0                                       | 16163                                            | 0.30                                              | ---                             | ---  | ---  | --- | --- | --- | --- | --- | 0.33 | --- | ---  | --- | ---           | 0.19                           | 0.35                       | 0.14 |
| #3                          | 5/7/83     | G     | n.r.                                               | 961                                           | 0.133                                            | 28.3                                       | 15783                                            | 0.17                                              | 12                              | 0.02 | ---  | --- | --- | --- | --- | --- | 0.91 | --- | ---  | --- | ---           | 0.41                           | 0.59                       | 0.13 |
| Canterra Rainbow Lake       |            |       |                                                    |                                               |                                                  |                                            |                                                  |                                                   |                                 |      |      |     |     |     |     |     |      |     |      |     |               |                                |                            |      |
| #1                          | 8/7/83     | G     | n.r.                                               | 1215                                          | 0.186                                            | 41.9                                       | 49368                                            | 0.46                                              | ---                             | ---  | ---  | --- | --- | --- | --- | --- | 0.97 | --- | ---  | --- | ---           | ---                            | 2.1                        | 0.88 |
| #2                          | 9/7/83     | G     | n.r.                                               | 1215                                          | 0.180                                            | 43.1                                       | 50769                                            | 0.48                                              | ---                             | ---  | ---  | --- | --- | --- | --- | --- | 1.7  | --- | ---  | --- | ---           | 0.17                           | 2.8                        | 0.82 |
| #3                          | 10/7/83    | G     | n.r.                                               | 1214                                          | 0.173                                            | 42.3                                       | 49900                                            | 0.49                                              | 27                              | ---  | ---  | --- | --- | --- | --- | --- | 1.9  | --- | ---  | --- | ---           | 0.10                           | 2.0                        | 0.81 |
| Esso Quirk Creek            |            |       |                                                    |                                               |                                                  |                                            |                                                  |                                                   |                                 |      |      |     |     |     |     |     |      |     |      |     |               |                                |                            |      |
| #1                          | 23/11/83   | G     | 1.03                                               | 929                                           | 0.160                                            | 79.9                                       | 128179                                           | 0.35                                              | ---                             | ---  | ---  | --- | --- | --- | --- | --- | ---  | --- | ---  | --- | ---           | 1.9                            | 9.1                        | 1.8  |
| #2                          | 24/11/83   | G     | 1.03                                               | 919                                           | 0.176                                            | 79.5                                       | 127453                                           | 0.34                                              | ---                             | ---  | ---  | --- | --- | --- | --- | --- | ---  | --- | ---  | --- | ---           | 0.55                           | 5.0                        | 1.9  |
| #3                          | 25/11/83   | G     | 1.07                                               | 912                                           | 0.153                                            | 77.8                                       | 126751                                           | 0.34                                              | ---                             | ---  | ---  | --- | --- | --- | --- | --- | ---  | --- | ---  | --- | ---           | 4.1                            | 4.6                        | 0.09 |

G borosilicate glass liner  
 • HCF/d  
 n.r. not recorded  
 -- worst case possibility  
 \*\*\* impinger contents could not be evaporated to dryness  
 + temperature specified by Alberta Stack Sampling Code

+ additional sampling scheduled for November 1986 to confirm this result





## VI. DISCUSSION OF RESULTS

Precautions were taken during sample collection, recovery and analysis to minimize contamination from equipment and chemicals used in the field and laboratory. Rigorous Pre-Test and Preliminary Field Testing Programs developed during earlier investigations (1,2) helped to establish the extent of the background levels of the elements of interest to be expected in the distilled water and nitric acid and on the filters used during this study. Recoveries of metals from spiked filters and liquids plus a three month shelf life study of spiked liquids provided a basis for assessing the quality assurance/quality control (QA/QC) program in the analytical laboratory.

### A. QUALITY ASSURANCE/QUALITY CONTROL

#### 1. Recoveries From Spiked Filters and Liquids

A review of Tables 5.1 and 5.2 shows that recoveries of metals from spiked filters and liquids were within the limits to be expected for such complex synthetic systems generated in the laboratory. Without much additional work it is not possible to comment on any potential interference and/or matrix effects that could influence recovery efficiencies from spiked samples. It must be emphasized that field filters and liquids never contained all 29 elements simultaneously.

Recovery efficiencies in the 50% range reported for

- cobalt (Co) from solutions
- germanium (Ge) from solutions
- titanium (Ti) from filters and solutions

are probably indicative of half level spiking rather than interference and/or matrix effects.

## 2. Shelf Life of Liquids

A 3 month shelf life study was carried to determine whether any losses of metallic species could occur during storage of original field liquids and samples prepared for analysis as a result of adsorption on container walls. Solutions of the 29 metals under investigation provided the low and high concentrations in 0.1 M and 6 M nitric acid as summarized in Table 6.1.

Samples of the liquids, stored in new borosilicate glass bottles normally used for transporting

- probe and nozzle
- impinger

catches from the field to the laboratory, were analyzed after 3, 6 and 11 week intervals. The results of this investigation are provided in Tables 6.2 to 6.4. An examination of these data indicates that there are no recognizable trends that would indicate slow or sudden removal of any metallic species from 0.1 M or 6 M nitric acid solutions. The fluctuations in the

Table 6.1 Preparation of Low and High Concentration Shelf Life  
Study Solutions Using 1000 ppm Standards

|    |            | Low Range                  |                                   | High Range                 |                                   |
|----|------------|----------------------------|-----------------------------------|----------------------------|-----------------------------------|
|    |            | Amount<br>Added<br>$\mu$ L | Resulting<br>Concentration<br>ppm | Amount<br>Added<br>$\mu$ L | Resulting<br>Concentration<br>ppm |
| Ag | Silver     | 100                        | 0.20                              | 500                        | 1.0                               |
| Al | Aluminum   | 5000                       | 10                                | 20000                      | 40                                |
| As | Arsenic    | 10                         | 0.02                              | 25                         | 0.05                              |
| B  | Boron      | 4 mL of<br>10,000 ppm      | 80                                | 12.5 mL of<br>10,000 ppm   | 250                               |
| Be | Beryllium  | 100                        | 0.20                              | 500                        | 1.0                               |
| Cd | Cadmium    | 100                        | 0.20                              | 500                        | 1.0                               |
| Co | Cobalt     | 500                        | 1.0                               | 4000                       | 8.0                               |
| Cr | Chromium   | 500                        | 1.0                               | 4000                       | 8.0                               |
| Cu | Copper     | 500                        | 1.0                               | 4000                       | 8.0                               |
| Fe | Iron       | 500                        | 1.0                               | 4000                       | 8.0                               |
| Ga | Gallium    | 5000                       | 10                                | 20000                      | 40                                |
| Ge | Germanium  | 5000                       | 10                                | 20000                      | 40                                |
| Hg | Mercury    | 10                         | 0.02                              | 50                         | 0.10                              |
| In | Indium     | 5000                       | 10                                | 20000                      | 40                                |
| Li | Lithium    | 100                        | 0.20                              | 500                        | 1.0                               |
| Mn | Manganese  | 100                        | 0.20                              | 500                        | 1.0                               |
| Mo | Molybdenum | 1000                       | 2.0                               | 5000                       | 10                                |
| Ni | Nickel     | 500                        | 1.0                               | 4000                       | 8.0                               |
| Pb | Lead       | 500                        | 1.0                               | 4000                       | 8.0                               |
| Sb | Antimony   | 1000                       | 2.0                               | 5000                       | 10                                |
| Sc | Scandium   | 2500                       | 5.0                               | 10000                      | 20                                |
| Se | Selenium   | 10                         | 0.02                              | 25                         | 0.05                              |
| Sn | Tin        | 5000                       | 10                                | 20000                      | 40                                |
| Sr | Strontium  | 100                        | 0.20                              | 500                        | 1.0                               |
| Te | Tellurium  | 1000                       | 2.0                               | 5000                       | 10                                |
| Ti | Titanium   | 10000                      | 20                                | 20000                      | 40                                |
| Tl | Thallium   | 1000                       | 2.0                               | 5000                       | 10                                |
| V  | Vanadium   | 50                         | 0.10                              | 200                        | 0.40                              |
| Zn | Zinc       | 100                        | 0.20                              | 500                        | 1.0                               |

Table 6.2 Per Cent Recoveries of Metals From Shelf Life Study  
Solutions Three Weeks After Preparation

|    |            | 0.1 M HNO <sub>3</sub> |            | 6 M HNO <sub>3</sub> |            |
|----|------------|------------------------|------------|----------------------|------------|
|    |            | Low Range              | High Range | Low Range            | High Range |
| Ag | Silver     | 85                     | 99         | 85                   | 111        |
| Al | Aluminum   | 99                     | 103        | 99                   | 103        |
| As | Arsenic    | 100                    | 70         | 100                  | 84         |
| B  | Boron      | 55*                    | 82*        | 39*                  | 72*        |
| Be | Beryllium  | n.d.                   | 89         | 25                   | 82         |
| Cd | Cadmium    | 90                     | 96         | 85                   | 94         |
| Co | Cobalt     | 93                     | 89         | 91                   | 85         |
| Cr | Chromium   | 91                     | 106        | 91                   | 104        |
| Cu | Copper     | 93                     | 96         | 91                   | 95         |
| Fe | Iron       | 96                     | 91         | 110                  | 93         |
| Ga | Gallium    | 98                     | 88         | 89                   | 83         |
| Ge | Germanium  | 93                     | 95         | 93                   | 88         |
| Hg | Mercury    | 100                    | 100        | 100                  | 100        |
| In | Indium     | 107                    | 95         | 98                   | 88         |
| Li | Lithium    | 95                     | 99         | 90                   | 104        |
| Mn | Manganese  | 105                    | 96         | 100                  | 96         |
| Mo | Molybdenum | 90                     | 94         | 110                  | 97         |
| Ni | Nickel     | 94                     | 103        | 90                   | 100        |
| Pb | Lead       | 81                     | 100        | 74                   | 98         |
| Sb | Antimony   | 81                     | 146        | 84                   | 136        |
| Sc | Scandium   | 88                     | 85         | 85                   | 85         |
| Se | Selenium   | **                     | **         | **                   | **         |
| Sn | Tin        | 100                    | 105        | 110                  | 110        |
| Sr | Strontium  | 45                     | 92         | 40                   | 85         |
| Te | Tellurium  | 115                    | 101        | 80                   | 91         |
| Ti | Titanium   | 70                     | 73         | 70                   | 75         |
| Tl | Thallium   | 90                     | 87         | 85                   | 83         |
| V  | Vanadium   | 100                    | 143        | 30                   | 23         |
| Zn | Zinc       | 90                     | 99         | 140                  | 114        |

\* - spiked with bad standard

\*\* - possibly interference

n.d. - not detected

Table 6.3 Per Cent Recoveries of Metals From Shelf Life Study  
Solutions Six Weeks After Preparation

|    |            | 0.1 M HNO <sub>3</sub> |            | 6 M HNO <sub>3</sub> |            |
|----|------------|------------------------|------------|----------------------|------------|
|    |            | Low Range              | High Range | Low Range            | High Range |
| Ag | Silver     | 41                     | 35         | 58                   | 80         |
| Al | Aluminum   | 118                    | 110        | 120                  | 120        |
| As | Arsenic    | 112                    | 115        | 136                  | 115        |
| B  | Boron      | 113                    | 200        | 100                  | 125        |
| Be | Beryllium  | 97                     | X          | 97                   | X          |
| Cd | Cadmium    | 90                     | 91         | 90                   | 87         |
| Co | Cobalt     | 98                     | 80         | 98                   | 80         |
| Cr | Chromium   | 105                    | 100        | 100                  | 90         |
| Cu | Copper     | 101                    | 91         | 96                   | 91         |
| Fe | Iron       | 90                     | 103        | 96                   | 160        |
| Ga | Gallium    | 98                     | 90         | 95                   | 90         |
| Ge | Germanium  | X                      | 84         | 95                   | 103        |
| Hg | Mercury    | 100                    | 120        | 100                  | 120        |
| In | Indium     | 108                    | 97         | 103                  | 99         |
| Li | Lithium    | 99                     | 105        | 100                  | 115        |
| Mn | Manganese  | 99                     | 105        | 97                   | 105        |
| Mo | Molybdenum | 100                    | 70         | 100                  | 70         |
| Ni | Nickel     | 95                     | 100        | 93                   | 100        |
| Pb | Lead       | 96                     | 100        | 94                   | 100        |
| Sb | Antimony   | 100                    | 95         | 92                   | 30         |
| Sc | Scandium   | 105                    | 108        | 110                  | 112        |
| Se | Selenium   | n.d.                   | n.d.       | n.d.                 | 55         |
| Sn | Tin        | 108                    | 110        | 110                  | 30         |
| Sr | Strontium  | 120                    | 75         | 120                  | 75         |
| Te | Tellurium  | 84                     | 95         | 89                   | 85         |
| Ti | Titanium   | 108                    | 95         | 98                   | 100        |
| Tl | Thallium   | 100                    | 90         | 110                  | 91         |
| V  | Vanadium   | 120                    | 155        | 100                  | 75         |
| Zn | Zinc       | 93                     | 90         | 101                  | 95         |

X - sample spoiled

n.d. - not detected

Table 6.4 Per Cent Recoveries of Metals From Shelf Life Study  
Solutions Eleven Weeks After Preparation

|    |            | 0.1 M HNO <sub>3</sub> |            | 6 M HNO <sub>3</sub> |            |
|----|------------|------------------------|------------|----------------------|------------|
|    |            | Low Range              | High Range | Low Range            | High Range |
| Ag | Silver     | 70                     | 60         | 95                   | 96         |
| Al | Aluminum   | 98                     | 98         | 101                  | 98         |
| As | Arsenic    | 135                    | n.a.       | 105                  | 102        |
| B  | Boron      | 200                    | 115        | 130                  | 115        |
| Be | Beryllium  | n.d.                   | 96         | n.d.                 | 91         |
| Cd | Cadmium    | 95                     | n.a.       | 90                   | 92         |
| Co | Cobalt     | 70                     | 96         | 70                   | 93         |
| Cr | Chromium   | 100                    | n.a.       | 16                   | 114        |
| Cu | Copper     | 100                    | n.a.       | 90                   | 93         |
| Fe | Iron       | 100                    | n.a.       | 220                  | 103        |
| Ga | Gallium    | 110                    | n.a.       | 100                  | 108        |
| Ge | Germanium  | 110                    | n.a.       | 100                  | 105        |
| Hg | Mercury    | 200                    | n.a.       | 200                  | 120        |
| In | Indium     | 110                    | n.a.       | 104                  | 100        |
| Li | Lithium    | 75                     | 97         | 95                   | 108        |
| Mn | Manganese  | 100                    | n.a.       | 100                  | 90         |
| Mo | Molybdenum | 115                    | n.a.       | 100                  | 105        |
| Ni | Nickel     | 90                     | n.a.       | 90                   | 94         |
| Pb | Lead       | 90                     | n.a.       | 90                   | 98         |
| Sb | Antimony   | 80                     | 90         | 80                   | 84         |
| Sc | Scandium   | 70                     | 80         | 64                   | 80         |
| Se | Selenium   | 65                     | n.a.       | 60                   | 26         |
| Sn | Tin        | 100                    | 113        | 110                  | 100        |
| Sr | Strontium  | 115                    | n.a.       | 90                   | 112        |
| Te | Tellurium  | 90                     | n.a.       | 80                   | 87         |
| Ti | Titanium   | 37                     | 53         | 38                   | 58         |
| Tl | Thallium   | 85                     | n.a.       | 85                   | 99         |
| V  | Vanadium   | 90                     | n.a.       | 60                   | 125        |
| Zn | Zinc       | 80                     | 92         | 135                  | 100        |

n.a. - not analyzed

n.d. - not detected

efficiencies of recovery generally ranged within the limits established by earlier short term recovery investigations (1,2,4).

## B. PLANT TESTS

Since above and below average recoveries of some metals occurred randomly during this and earlier investigations (1,2,4) no corrections could be made to measured metal concentrations in any of the liquids subjected to atomic absorption (AA) procedures.

### 1. Canadian Superior-Harmattan Gas Plant

Significant levels of arsenic, copper, iron, manganese, nickel and zinc were "established" in the Harmattan incinerator stack gases. Chromium was detected once out of three tests at a concentration just above the detection limit as shown Figure 5.1.

### 2. Gulf-Nevis Gas Plant

The presence of aluminum, arsenic, iron, manganese and zinc was "established" in the gases exhausted from the incinerator stack at the Gulf-Nevis facility. As illustrated in Figure 5.2, chromium and nickel were "detected" once out of three tests at concentrations exceeding the detection limits. Although the level of chromium was just below the criterion of "3 times the limit of detection", it has been included in Table 5.3 as a metal whose presence was "established" to illustrate the "worst case" scenario.



### 3. Petro Canada-Gold Creek Gas Plant

The concentrations of aluminum, arsenic, iron and zinc in the Gold Creek incinerator stack exhaust gases met the criteria that "establish" the definite presence of a metal. As shown in Figure 5.3 there were no other metallic species "detected" at this plant.

### 4. Canterra-Rainbow Lake Gas Plant

Only aluminum, iron and zinc were positively "identified" in the incinerator stack gases at the Rainbow Lake sour gas plant. Since it was difficult to confirm the "detection" of chromium and copper, these components were not illustrated in Figure 5.4 as metals whose presence was "detected" in the Rainbow Lake incinerator stack gases.

### 5. Esso-Quirk Creek Gas Plant

Chromium, iron and zinc were "consistently present" in the gases exhausted from the Quirk Creek incinerator stack. Also a significantly high level of mercury was "established" during test #1. On the basis of the source sampling conducted at nine other sour gas plants (1,2 and this study), the detection of a significant amount of mercury on a filter from one test was highly unexpected. Consequently, arrangements were made to retest the Quirk Creek Gas Plant before the end of November 1986. The resampling program will focus only on mercury collection.

There were sporadic "detections" of cadmium (1 out of 3 tests) and copper (1 out of 3 tests). Molybdenum and strontium were excluded from Figure 5.5 as metals whose presence was "detected" in the Quirk Creek incinerator stack gases since their concentrations were negligibly above the limits of detection in one out of three tests.

### C. TOTAL PARTICULATE MATTER EMISSIONS

According to the Alberta Source Sampling Code (3) a source test conducted to determine particulate matter emission rates shall include two emission values:

- the first emission rate based on the amount of particulate matter catch in the front-half of the train (in nozzle, probe and filter)
- the second emission rate which is based on the total of filtered material in the front-half of the train plus any particulate matter collected in the impinger solutions.

An examination of Table 5.3 reveals that pure metal emissions represent a small fraction of the sampling train front-end emission rate values. Such a relationship is to be expected since these elements are probably discharged as oxides, sulfates or silicates whose formula weights are roughly 2 to 4 times higher than those of the pure metals. Agreement between the elemental and front-half emission rates would be improved significantly by accounting for the presence of calcium (Ca), magnesium (Mg), potassium (K), silicon (Si) and sodium (Na) in stack emissions. Collection of sulphur (S) in the probe and nozzle as well as on the filter can influence the differences between pure metal and front-half emission rates.

The total emission rates are certainly overestimated if specified procedures are followed (3). Impinger solutions could not be evaporated to dryness at 100°C as prescribed by AERM (3).

No matter how long drying was carried out at 100°C, it was impossible to derive a dry residue from the oily film that remained in the tared beaker. It is suspected that sulfuric acid was generated when sulfur dioxide ( $\text{SO}_2$ ) was absorbed by the 6 M nitric acid impinger solutions. It is also possible that some quantities of sulfuric acid are generated as a result of trace emissions of sulfur trioxide ( $\text{SO}_3$ ). Consequently, it was impossible to establish a constant weight since sample weights increased during the weighing operation as water vapor from the ambient air was absorbed.

#### D. COMPARISON OF PLANT OPERATIONS

When the objectives of the trace element emission studies at sour gas plant incinerator stacks were developed initially during the summer of 1982 it was anticipated that incinerator stack emissions could be correlated to plant operating conditions and/or geological formations from where the raw sour gases were derived. To facilitate such potential correlations ERCB inspectors H. Bratrud and/or J. Chudleigh were present at each plant during each testing period. In addition to recording plant production data (tabulated in Appendix IV) before, during and for several hours after each test run, they were responsible for obtaining process flow sheets and any descriptive technical literature that would be helpful in the analysis of plant operating characteristics.

Earlier reports (1,2,4) provided comprehensive process descriptions of the sour gas plants where sampling programs had been conducted. It was not possible to relate any of the metals that were "detected" or whose presence was "established" in the incinerator stack emissions or process lines to the formations from which raw sour gas streams were obtained. Additions of

- bactericides
- corrosion inhibitors
- scale inhibitors

at the well heads and during processing were suspected of influencing the types and concentrations of metallic species that were found at different locations in any typical sour gas plant (1,2,4). Since detailed process analyses during the earlier studies were not effective in providing correlation of measured incinerator stack emissions (1,2) or potential emissions from flare stacks (4), process descriptions have been limited to presentation of schematic or detailed flow diagrams.

#### 1. Process Descriptions

The processes and chemistry associated with the production of hydrogen sulfide free sales gas have been discussed in some detail in earlier publications (1,2,4).

Figures 6.1 and 6.2 provide a schematic representation of the operation of the Petro Canada-Gold Creek Gas Plant.

The complexity of a typical sour gas plant is well illustrated by Figures 6.3 to 6.7 which provide significant details about the Canterra-Rainbow Lake facility.







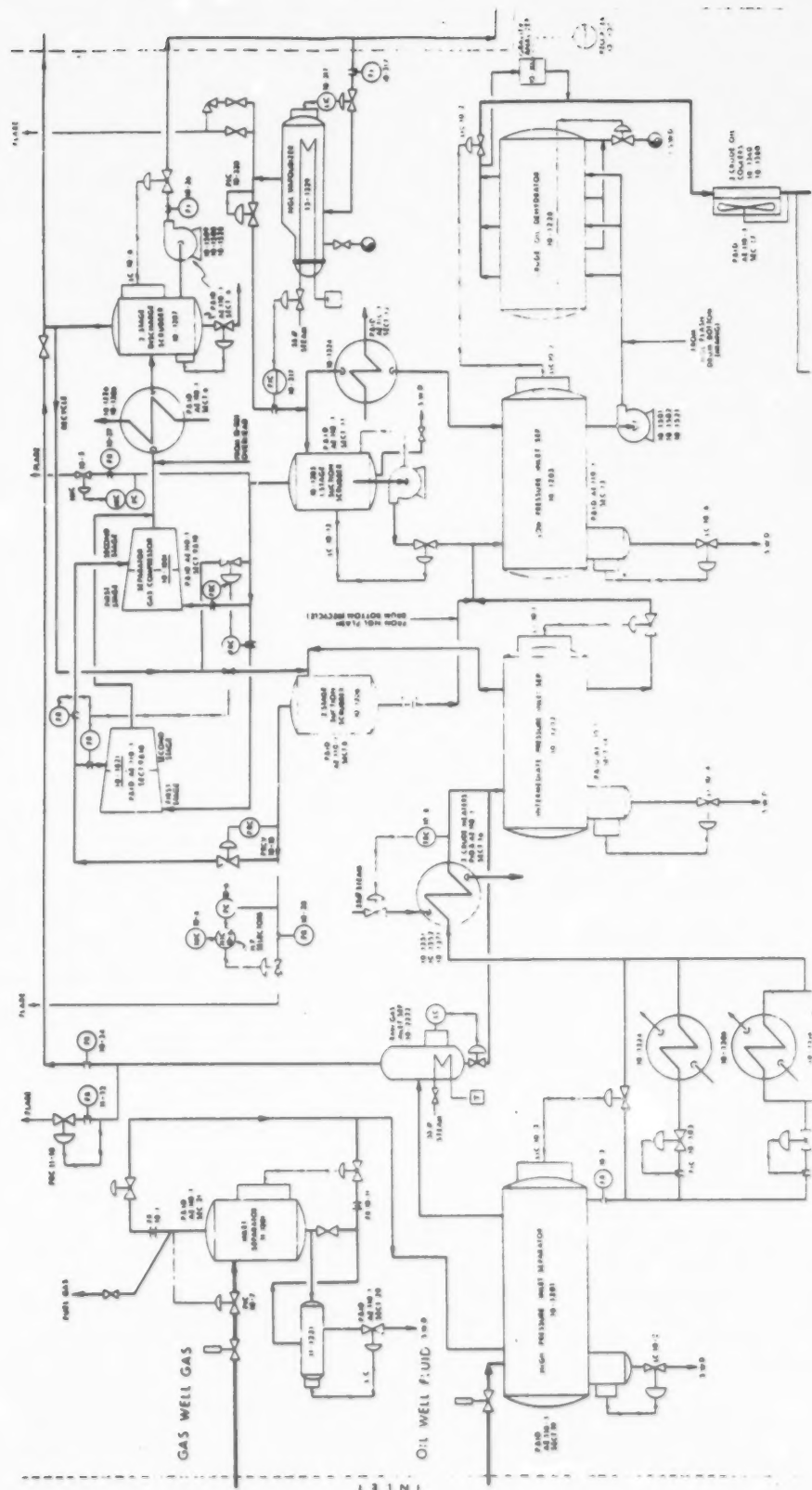


Figure 6.3: Detailed Flow Diagram for the Canterra-Rainbow Lake Gas Plant (Oil-Gas Flash Separation Section)



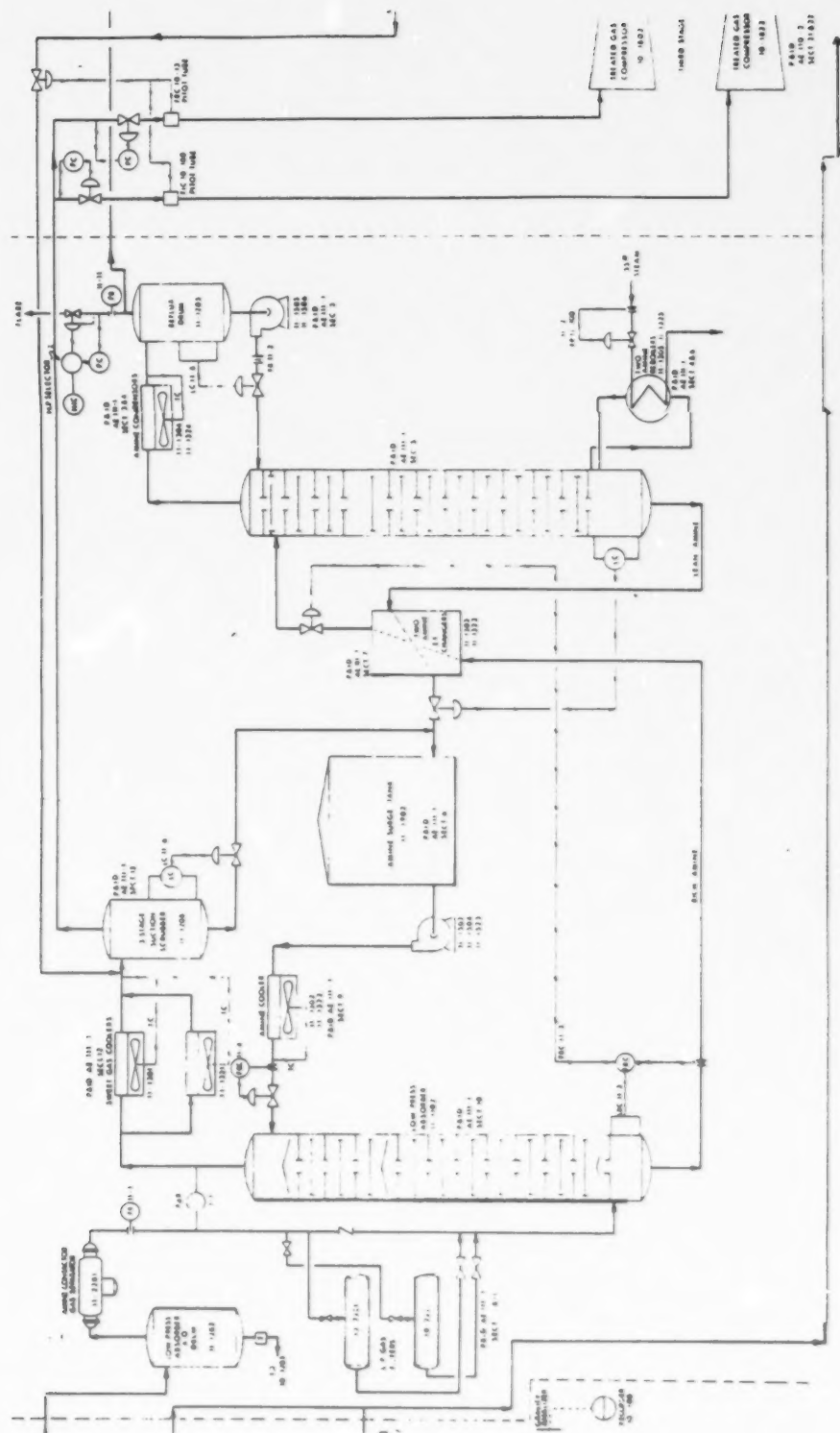


Figure 6.4: Detailed Flow Diagram for the Canterra-Rainbow Lake Gas Plant (Gas Sweetening Section)  
(H<sub>2</sub>S and CO<sub>2</sub> Removal Using Aqueous Amine Scrubbing)

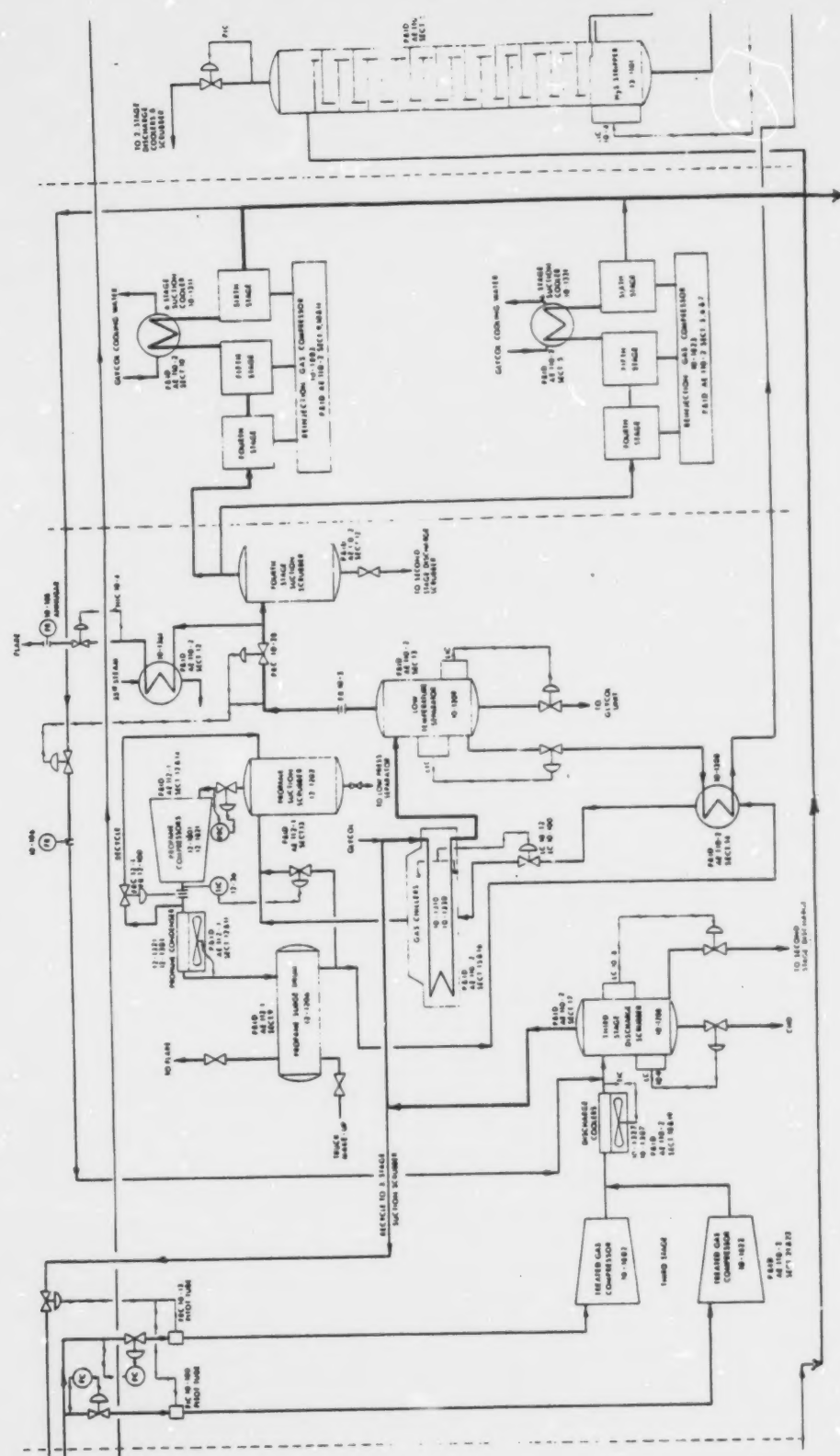


Figure 6.5: Detailed Flow Diagram for the Canterra-Rainbow Lake Gas Plant (Sweet Gas-NGL Separation Section on Left and Gas Injection Section on Right)





Figure 6.8 represents a very simplified schematic process diagram for the Esso-Quirk Creek installation.

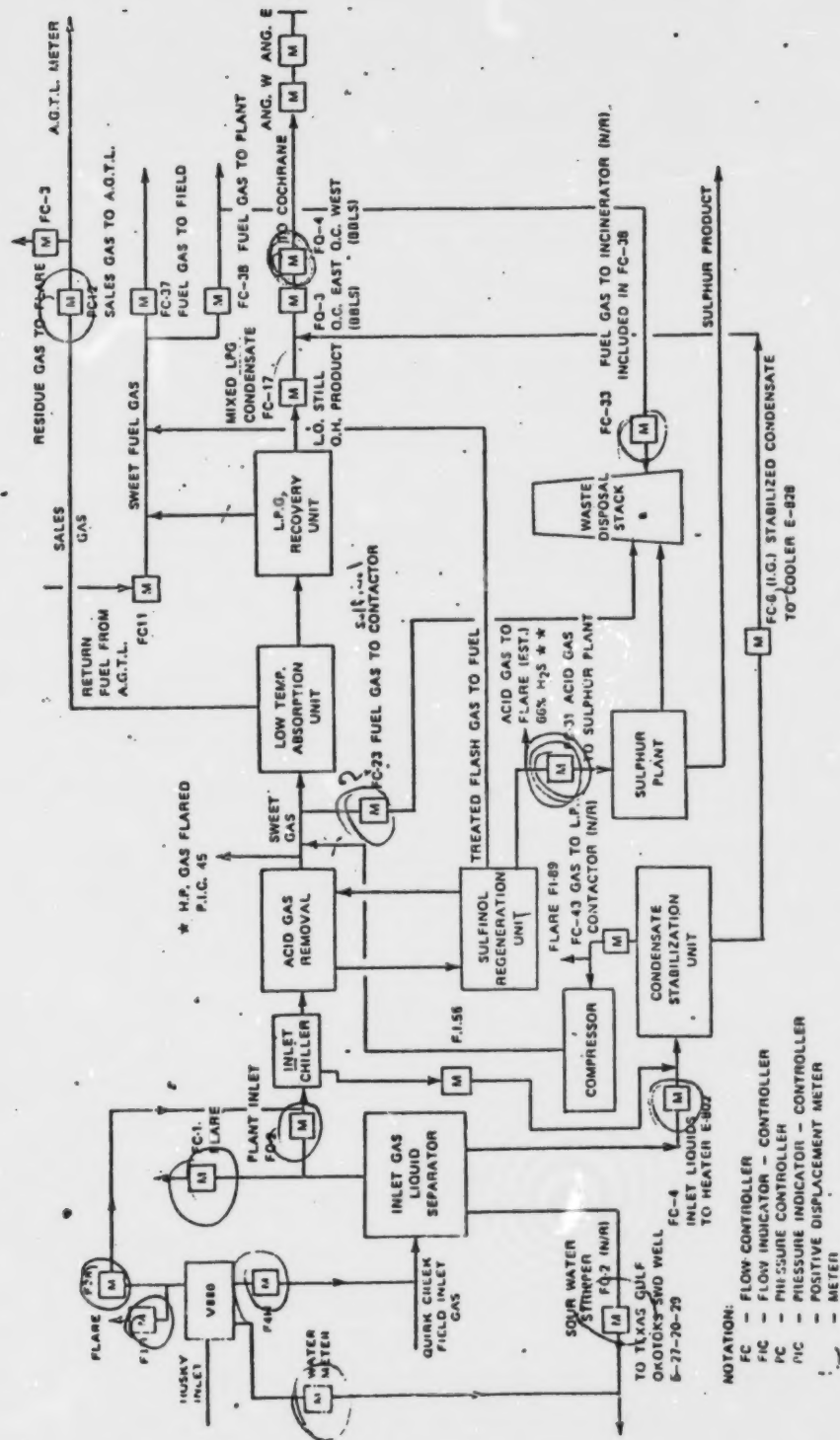
Without a systematic accounting of metal inputs into the process streams as a result of additions of

- processing components
- bactericides
- corrosion inhibitors
- scale inhibitors
- antifoam agents

it is not possible to relate emissions from incinerator stacks to plant conditions during the testing periods.

## 2. Comparison of Emission Rates

An examination of Table 5.3 suggests that the particulate matter emission rates based on the catches in the front half of the sampling train (in nozzle, probe and filter) are highly dependent on the average stack volumetric flow rates. On the other hand, the total emission rates, which are determined by the front half catches plus what is collected in the impinger solutions, appear to be related to the levels of sulfur dioxide ( $\text{SO}_2$ ) in the incinerator stack gases. Such an implied dependence on  $\text{SO}_2$  concentration supports the contention that sulfur dioxide can be converted to sulfuric acid ( $\text{H}_2\text{SO}_4$ ) by reaction with 6 M nitric acid ( $\text{HNO}_3$ ) in the impinger solutions. It was impossible to evaporate impinger solutions to dryness at  $100^\circ\text{C}$  as prescribed by AERM(3). An oily film that absorbed water vapor during weighing was always produced instead of a dry residue.



\* GAS TO FLARE (H.P.) THROUGH PIC 45 IS CALCULATED AS FOLLOWS: READ CHART OFF FC-31 FOR THE PERIOD OF FLARING TIME - "A" HEAD INLET CHILLER LIQUID CHART AND CONVERT RESULTANT GALLONS TO GAS EQUIVALENT MCF - "B". RECORD H<sub>2</sub>S & CO<sub>2</sub> ANALYSIS FOR THE DAY (ABOUT 13% - "C"). THEN A - B - C = MCF FLARED THROUGH PIC 45.

† GAS TO FLARE (H.P.) CALCULATED BY THE READING OF THE FLOW OF FC-31 FOR PERIOD OF FLARING & TIME AS COMPARED TO NORMAL FLOW RATE.

992.315

Figure 6.8: Schematic Process Diagram for the Esso-Quirk Creek Gas Plant



Table 6.5 provides a comparison of average concentrations and emission rates of metals whose presence was "established" in the gases exhausted from the incinerator stacks at the five plants under investigation. Without a good appreciation of the compositions and amounts of chemical additives used to control bacterial growth, corrosion, scale formation and foaming, it is not possible to explain the presence of any of the metals that were identified positively in the effluent gas streams. No doubt, iron emissions occur as a result of corrosion and/or erosion of process equipment and pipes.

#### E. RANDOM ERROR ANALYSIS

A comprehensive error analysis can now be developed to evaluate random error limits on the elemental and total particulate emission rates due to

- variations in equipment and personnel during field activities
- variations in equipment and personnel in the laboratory.



Table 6.5: Comparison of Average Concentrations and Emission Rates of Metals Found in Gases From Incinerator Stacks at the Canadian Superior-Harmattan, Gulf-Nevis, Petro Canada-Gold Creek, Canterra-Rainbow Lake and Esso-Quirk Creek Gas Plants.

| Metal     | Canadian Superior-Harmattan           |                       | Gulf-Nevis                          |                       | Petro Canada-Gold Creek            |                       | Canterra-Rainbow Lake               |                       | Esso-Quirk Creek                     |                       |
|-----------|---------------------------------------|-----------------------|-------------------------------------|-----------------------|------------------------------------|-----------------------|-------------------------------------|-----------------------|--------------------------------------|-----------------------|
|           | Volumetric Flow Rate*<br>137,500±2600 | Average Concentration | Volumetric Flow Rate<br>45,600±3600 | Average Concentration | Volumetric Flow Rate<br>16,000±200 | Average Concentration | Volumetric Flow Rate<br>51,500±3100 | Average Concentration | Volumetric Flow Rate<br>126,800±1800 | Average Concentration |
|           | g/h                                   | ug/rcf**              | g/h                                 | ug/rcf                | g/h                                | ug/rcf                | g/h                                 | ug/rcf                | g/h                                  | ug/rcf                |
| Aluminum  | ---                                   | ---                   | 22 ± 29                             | 18 ± 24               | 17 ± 21                            | 4.8 ± 6.2             | 14.3 ± 18.8                         | 11 ± 14               | ---                                  | ---                   |
| Arsenic   | 0.06±0.04                             | 0.12±0.09             | ---                                 | ---                   | 0.06±0.02                          | 0.02±0.01             | ---                                 | ---                   | ---                                  | ---                   |
| Beryllium | ---                                   | ---                   | ---                                 | ---                   | ---                                | ---                   | ---                                 | ---                   | ---                                  | ---                   |
| Chromium  | ---                                   | ---                   | ---                                 | ---                   | ---                                | ---                   | ---                                 | ---                   | ---                                  | ---                   |
| Copper    | 3.2 ± 3.1                             | 6.3 ± 5.8             | ---                                 | ---                   | ---                                | ---                   | ---                                 | 1.7 ± 0.06            | 3.5 ± 0.2                            | ---                   |
| Iron      | 320 ± 510                             | 640 ± 1000            | 20 ± 14                             | 16 ± 11               | 2.2 ± 1.0                          | 0.62±0.29             | 2.0 ± 0.66                          | 1.5 ± 0.5             | 1.9 ± 0.07                           | 4.0 ± 1.4             |
| Mercury   | ---                                   | ---                   | ---                                 | ---                   | ---                                | ---                   | ---                                 | 2.8 ± 4.6             | 5.8 ± 9.7                            | ---                   |
| Manganese | 1.6 ± 1.9                             | 3.2 ± 3.8             | 0.31±0.02                           | 0.24±0.01             | ---                                | ---                   | ---                                 | ---                   | ---                                  | ---                   |
| Nickel    | 2.2 ± 0.06                            | 4.4 ± 0.06            | ---                                 | ---                   | ---                                | ---                   | ---                                 | ---                   | ---                                  | ---                   |
| Zinc      | 75 ± 130                              | 150 ± 250             | 2.5 ± 0.2                           | 1.9 ± 0.2             | 0.83±0.50                          | 0.24±0.15             | 0.16 ± 0.06                         | 0.12±0.05             | 1.02±0.82                            | 2.2 ± 1.8             |

\* in acfm = actual cubic feet per minute at stack temperature and pressure

\*\* rcf = reference cubic feet at 25°C and 1 atmosphere

+ additional sampling scheduled for November 1986 to confirm this result

## VII CONCLUSIONS AND RECOMMENDATIONS

Iron, manganese, nickel and zinc were "consistently present" in the incinerator stack gases at the Canadian Superior-Harmattan gas plant. Arsenic and copper were found once out of three tests at concentrations meeting the criteria of "presence in significant amounts".

The gases emitted from the Gulf-Nevis facility carry "established" levels of aluminum, iron, manganese and zinc.

The presence of aluminum, arsenic, iron and zinc has been "established" in the incinerator stack emissions from the Petro Canada-Gold Creek sour gas plant.

Only aluminum, iron and zinc were identified at sufficiently high concentrations to "establish" their presence in the incinerator stack gases exhausted at the Canterra-Rainbow Lake installation.

Significant levels of chromium, iron and zinc were "established" in the gases leaving the incinerator stack at the Esso-Quirk Creek complex. Mercury appeared once out of three tests on a filter at a level defining definite presence. This detection of mercury on a filter, once out of 35 tests conducted at 10 sour gas plants, represents an anomalous incinerator stack condition which should be investigated in more detail. The Energy Resources Conservation Board agreed that the Quirk Creek gas plant should be retested to determine whether the presence of mercury was "established" in the incinerator stack emissions.

Arrangements were made to conduct additional source sampling tests in November, 1986.

It is not possible to assess the impact of the incinerator stack emissions on downwind receptors without reliable short-range atmospheric dispersion modelling. Predicted ground level concentrations and deposition rates should be validated through a comprehensive ambient air sampling program in urban and rural areas as well as at upwind and downwind locations from sour gas plant incinerator stacks.

Ambient air sampling programs must involve high-volume samplers that have been modified to ensure collection of sub-micron particulate matter at efficiencies that are much higher than those obtainable with units that are currently available on the market.

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APPENDIX I

GAS CHROMATOGRAPH CALIBRATION GAS ANALYSIS  
and  
TECHNICAL DATA ON ULTRA-PURE QM-A QUARTZ FILTERS

June 29, 1983

ENERGY RESOURCES CONSERVATION BOARD  
640 - Fifth Avenue S.W.  
CALGARY, Alberta  
T2P 3G4

ATTENTION: Dr. R. Thimm

Dear Dr. Thimm,

Re: Preparation of Standard Gas Samples

In accordance with our conversation of June 28th, we have prepared another standard gas mixture containing carbon dioxide, carbon monoxide and air. The analysis is the same as in the previous case, namely:

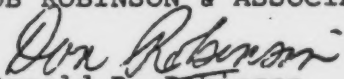
|                 | <u>Mole Fraction</u> |
|-----------------|----------------------|
| Carbon Dioxide  | 0.10140              |
| Carbon Monoxide | 0.00933              |
| Air             | 0.88927              |

The sample was placed in a new 250 cm<sup>3</sup> gas sampling pipette equipped with a side tube closed with a rubber septum. This filled pipette was then delivered to the ERCB Laboratory in the Chemical - Mineral Building at the University of Alberta on Wednesday afternoon, June 29th.

I am enclosing a statement for our services in this connection. We appreciate the opportunity to be of assistance to you.

Yours very truly,

DB ROBINSON & ASSOCIATES LTD.

  
Donald B. Robinson,  
President

DBR/byr  
Enclosure

**LARRY G. WEST**  
Technical Services Specialist

Whatman Laboratory Products Inc

9 Bridewell Place, Clifton, NJ 07014  
201-773-5800 Telex 133426



#### QM-A QUARTZ TECHNICAL DATA

|                                 |                                                                               |
|---------------------------------|-------------------------------------------------------------------------------|
| Basis Weight                    | 85 gm/m <sup>2</sup>                                                          |
| Thickness                       | 0.45 mm                                                                       |
| Particle retention efficiency   | 99.999% retention<br>(0.6 µm particles at 5cm/sec F.V.) or 0.001% penetration |
| Dry Tensile (1.5 cm wide strip) | 250 - 300 g                                                                   |
| Maximum Temperature             | 500° C                                                                        |
| Air flow rate                   | 800 litres/min<br>(for 400 cm <sup>2</sup> filter area at Δ p = 20 mm Hg)     |

N.B. 400 cm<sup>2</sup> is effective filtration area of 8" x 10" sheet

#### CHEMICAL PURITY

| Element | p.p.m. | Micrograms per sheet (8 x 10 in) |
|---------|--------|----------------------------------|
| Cd      | 0.23   | 1                                |
| Co      | 1.1    | 5                                |
| Cr      | 1.6    | 7                                |
| Cu      | 3.4    | 15                               |
| Fe      | 23.0   | 100                              |
| Mn      | 0.46   | 2                                |
| Ni      | 3.4    | 15                               |
| Pb      | 2.3    | 10                               |
| Zn      | 18.2   | 80                               |

All values typical subject to normal manufacturing tolerances.

#### TECHNICAL DATA ON

## ULTRA-PURE QM-A QUARTZ FILTERS

#### QM-A. THE NEW ULTRA-PURE QUARTZ FILTER FROM WHATMAN FOR AIR SAMPLING.

Whatman now introduce QM-A, an ultra-pure quartz (SiO<sub>2</sub>) microfibre filter for the most exacting work in air pollution monitoring. QM-A is heat-treated and entirely binder free and only a small amount (5%) of conventional borosilicate glass microfibres are added for papermaking purposes.

#### ULTRA-PURE - HIGH FLOW RATES

Ultra-pure QM-A is extremely low in heavy metal content, whilst offering the high flow rates and filtration efficiencies of conventional borosilicate glass microfibre filters. Trace level determinations in particulates can now be carried out with the utmost accuracy.

#### LOW IN ALKALINE EARTH METALS

Whatman QM-A contains virtually no alkaline earth metals and is therefore recommended for sampling and subsequent analysis of environments where acidic gases such as SO<sub>2</sub> and NO<sub>2</sub> are encountered. 'Artifact' production of sulphates and nitrates on the filter, is, thus, virtually eliminated with QM-A and critical analyses can now be conducted free from inaccuracies caused by artifact production with glass microfibre filters.

#### APPLICATIONS

Whatman QM-A is suitable for ambient and high temperature (max 500° C) air sampling of environments such as stacks, flue outlets and aerosols. Being ultrapure and containing low levels of elements important in pollution studies, Whatman QM-A is the filter of choice for critical analyses and trace level determinations, and it is especially suitable for analytical techniques such as atomic absorption spectroscopy and flame emission spectrophotometry.

The low background levels of heavy metals in QM-A also make it suitable for X-ray fluorescence techniques and neutron activation analyses

#### MINIMAL WEIGHT LOSS

QM-A is heat treated after manufacture to remove bound moisture and trace organic impurities and to ensure minimal weight loss on further heating. For accurate gravimetric results, as with any medium, it is essential, both before and after sampling, to condition the filter carefully before weighing.

#### AVAILABILITY

| Standard Sizes                     | Cat. No. |
|------------------------------------|----------|
| Circles: 3.2 cm dia                | 1851 032 |
| 3.7                                | 1851 037 |
| 4.7                                | 1851 047 |
| 5.5                                | 1851 055 |
| Sheets: 20.4 x 25.4 cm (8 x 10 in) | 1851 865 |

# QM-A QUARTZ ULTRA-PURE FILTERS DATA SHEET 860 QM-A A

## COMPARISON OF PHYSICAL CHARACTERISTICS AND CHEMICAL PURITY OF WHATMAN QM-A QUARTZ MICROFIBRE FILTERS, EPM1000, GF/A AND GRADE 41

### (1) PHYSICAL CHARACTERISTICS:

|                                                 | QM-A              | EPM1000          | GF/A             | No. 41                     |
|-------------------------------------------------|-------------------|------------------|------------------|----------------------------|
| Composition                                     | Quartz Microfibre | Glass Microfibre | Glass Microfibre | Cellulose (Cotton Linters) |
| Basis weight                                    | 85                | 80               | 53               | 85                         |
| Thickness (mm)                                  | 0.45              | 0.43             | 0.26             | 0.21                       |
| Dry Tensile <sup>1</sup> (g)                    | 250-300           | 742              | 430              | 2400                       |
| Sodium Flame Retention <sup>2</sup> (Nafla) (%) | 99.999            | 99.998           | 99.995           | 74                         |
| $\Delta P^4$ (mm Hg)                            | 3                 | 3                | 3                | 3                          |
| Temperature Resistance (Max. °C)                | 500               | 500              | 500              | 200                        |
| Air <sup>3</sup> Flow Rate at $\Delta P = 3$    | 120               | 120              | 120              | 120                        |
| Air <sup>3</sup> Flow Rate at $\Delta P = 20$   | 800               | 750              | 950              | 1150                       |

#### NOTES

<sup>1</sup> All values are 'typical' and subject to normal manufacturing tolerances.

<sup>2</sup> Tensile 1.5 cm wide strip.

<sup>3</sup> Sodium flame penetrometer to BS 4400 all values at 5cms/Sec F.V.

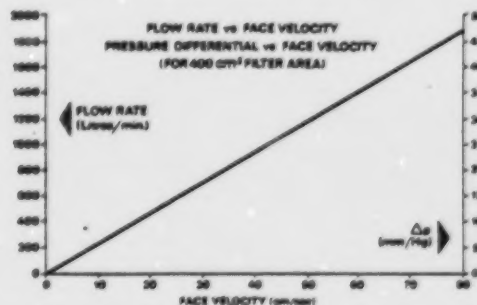
<sup>4</sup> Pressure differential across filter at 5cms/Sec F.V.

<sup>5</sup> Measured in litre/minute for air (values for 400 cm<sup>2</sup> area assuming no flow restriction imposed by holder).

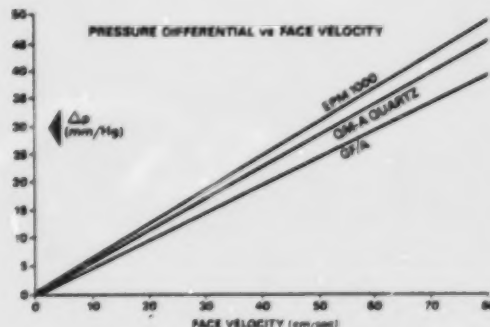
Key F.V. = Face Velocity

NB  $\Delta P$  figures at higher F.V.'s than 5 cms/sec vary considerably with grade of filter - see Air Pollution Monitoring brochure for graphs of  $\Delta P$  vs F.V.

### QM-A QUARTZ FILTER FLOW RATE



### COMPARISON OF QM-A QUARTZ, EPM1000 AND GF/A



### (2) CHEMICAL PURITY Concentrations given in $\mu\text{g}/\text{sheet}$ (8" x 10") and in p.p.m.

| Element | QM-A                       |        | EPM1000                    |        | GF/A                       |        | GRADE 41                   |        |
|---------|----------------------------|--------|----------------------------|--------|----------------------------|--------|----------------------------|--------|
|         | $\mu\text{g}/\text{sheet}$ | p.p.m. | $\mu\text{g}/\text{sheet}$ | p.p.m. | $\mu\text{g}/\text{sheet}$ | p.p.m. | $\mu\text{g}/\text{sheet}$ | p.p.m. |
| Cd      | 1.0                        | 0.23   | 2.1                        | 0.6    | 2.7                        | 1.0    | ND                         | ND     |
| Co      | 4.8                        | 1.1    | 1.24                       | 0.3    | 2.7                        | 1.0    | ND                         | ND     |
| Cr      | 7.0                        | 1.6    | 4.95                       | 1.2    | 0.55                       | 0.2    | 1.3                        | 0.3    |
| Cu      | 14.9                       | 3.4    | 2.9                        | 0.7    | 16.4                       | 6.0    | 1.75                       | 0.4    |
| Fe      | 100                        | 23     | 103                        | 25     | 275                        | 100    | 26.3                       | 6.0    |
| Mn      | 2.0                        | 0.46   | 4.95                       | 1.2    | 21.9                       | 8.0    | <0.22                      | <0.05  |
| Ni      | 14.9                       | 3.4    | 14.4                       | 3.5    | 16.4                       | 6.0    | ND                         | ND     |
| Pb      | 10.0                       | 2.3    | 10.3                       | 2.5    | 27                         | 10     | 0.9                        | 0.2    |
| Zn      | 60                         | 18.2   | 103                        | 25     | ND                         | ND     | 2.6                        | 0.6    |

KEY ND = NOT DETERMINED

NOTES Cellulose Data obtained from analysis of ash. Glass Data obtained from extraction under acid conditions.



**Whatman**

PAPER DIVISION

Whatman Laboratory Products Inc 9 Bridewell Place, Clifton, New Jersey 07014 USA Tel: (201) 773-5800 Sales Tel: (201) 777-4825 Telex: 133426

APPENDIX II

PREPARATION OF DEMINERALIZED WATER  
and  
ACTUAL LOT ANALYSIS (218042)  
for  
BAKER INSTRA-ANALYZED NITRIC ACID

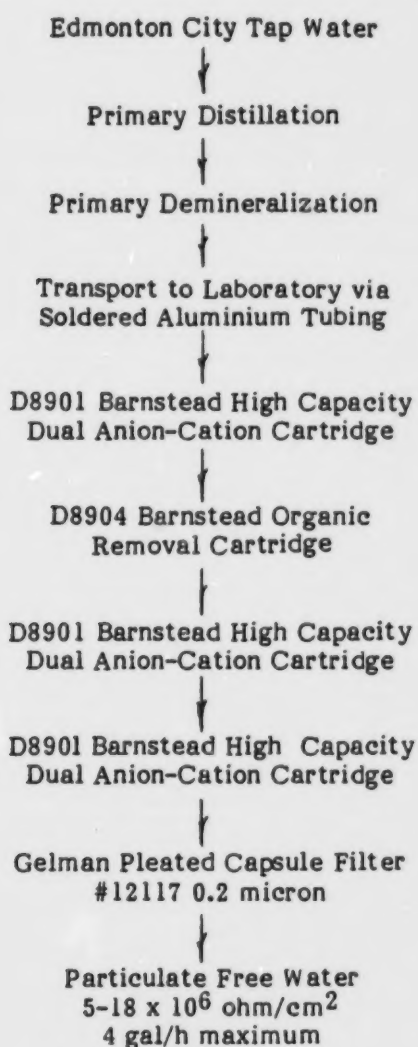


Figure II.1 Preparation of Demineralized Water by  
Energy Resources Conservation Board Laboratory,  
Edmonton, Alberta



## APPENDIX II

|                                                    |             |
|----------------------------------------------------|-------------|
| Assay (HNO <sub>3</sub> ) (by acid base titration) | 70.3%       |
| Appearance                                         | Passes test |
| Color (APHA)                                       | < 5         |
| Density at 20°C                                    | 1.426 gm/ml |
| Residue after ignition                             | 2 ppm       |

### Trace Impurities (ppm) (µg/g)

|                                 |         |                |          |
|---------------------------------|---------|----------------|----------|
| Chloride (Cl)                   | < 0.08  | Lead (Pb)      | 0.0002   |
| Phosphate (PO <sub>4</sub> )    | < 0.1   | Lithium (Li)   | < 0.02   |
| Sulphate (SO <sub>4</sub> )     | < 0.5   | Magnesium (Mg) | 0.02     |
| Aluminum (Al)                   | 0.05    | Manganese (Mn) | 0.0004   |
| Arsenic and Antimony<br>(as As) | < 0.005 | Mercury (Hg)   | < 0.0001 |
| Barium (Ba)                     | < 0.02  | Nickel (Ni)    | 0.003    |
| Boron (B)                       | 0.001   | Potassium (K)  | < 0.1    |
| Cadmium (Cd)                    | < 0.002 | Silicon (Si)   | 0.01     |
| Calcium (Ca)                    | 0.02    | Silver (Ag)    | < 0.0001 |
| Chromium (Cr)                   | 0.02    | Sodium (Na)    | 0.2      |
| Cobalt (Co)                     | 0.0002  | Strontium (Sr) | < 0.002  |
| Copper (Cu)                     | 0.0003  | Tin (Sn)       | 0.001    |
| Heavy Metals (as Pb)            | 0.05    | Zinc (Zn)      | < 0.002  |
| Iron (Fe)                       | 0.02    |                |          |

Table II.1 Actual Lot Analysis (218042) for Baker Instra-Analyzed Nitric Acid



APPENDIX III

FIELD SAMPLING DATA  
and  
ELEMENTAL EMISSION RATES

- 1) CLIENT NAME: ENERGY RESOURCES CONSERVATION BOARD  
LOCATION: Harmattan  
COMPANY: Canadian Superior Oil Ltd.
- 2) TEST NO: Prelim DATE: June 23, 1983
- 3) PRODUCTION: 3.68 MCF/d Sales Gas
- 4) BAROMETRIC PRESSURE: 26.30 (inches Hg)  
STATIC PRESSURE: -1.3 (inches H<sub>2</sub>O)  
STACK DIMENSIONS: DIAMETER (D) 8-5/6 (feet)
- 5) PITOT TUBE COEFFICIENT: 0.895  
METER CORRECTION FACTOR: 1.0  
NOZZLE DIAMETER: 0.3125 (inches)
- 6) GAS COMPOSITION: (percent by volume)  
CO<sub>2</sub> 10.23, O<sub>2</sub> 10.47, CO 0.0  
SO<sub>2</sub> 0.41, N<sub>2</sub> 77.96, Ar 0.93
- 7) NO. OF READINGS: 64  
TIME BETWEEN READINGS: I 3 II 5 min.  
TEST POINTS/TRVERSE: 16  
NO. OF TRAVERSES: 2
- 8) CONDENSED WATER: 342.97 (grams)  
WATER CAUGHT BY DRYING AGENTS: 5.31 (grams)  
MOISTURE CONTENT, B<sub>wo</sub>: 0.181
- 9) MOLECULAR WEIGHT OF GAS:  
30.31 DRY BASIS (lb<sub>m</sub>/lb mole)  
28.1 WET BASIS (lb<sub>m</sub>/lb mole)
- 10) VOLUME OF GAS SAMPLED: 86.10 (acf)
- 11) AVERAGE STACK VELOCITY: 38.09 (ft/s) AVG. TEMP: 1138 (°F)  
AVERAGE VOLUMETRIC FLOW RATE: 140047 (acfm)

TABLE 111.1 FIELD DATA SUMMARY SHEET





- 1) CLIENT NAME: ENERGY RESOURCES CONSERVATION BOARD  
LOCATION: Harmattan  
COMPANY: Canadian Superior Oil Ltd.
- 2) TEST NO: 1 DATE: June 24, 1983
- 3) PRODUCTION: 3.67 MCF/d Sales Gas
- 4) BAROMETRIC PRESSURE: 26.30 (inches Hg)  
STATIC PRESSURE: -1.3 (inches H<sub>2</sub>O)  
STACK DIMENSIONS: DIAMETER (D) 8-5/6 (feet)
- 5) PITOT TUBE COEFFICIENT: 0.895  
METER CORRECTION FACTOR: 1.0  
NOZZLE DIAMETER: 0.3125 (inches)
- 6) GAS COMPOSITION: (percent by volume)  
CO<sub>2</sub> 10.90, O<sub>2</sub> 9.13, CO 0.0  
SO<sub>2</sub> 0.65, N<sub>2</sub> 78.42, Ar 0.90
- 7) NO. OF READINGS: 64  
TIME BETWEEN READINGS: I 4.0 II 3.0min.  
TEST POINTS/TRVERSE: 16  
NO. OF TRAVERSES: 2
- 8) CONDENSED WATER: 310.656 (grams)  
WATER CAUGHT BY DRYING AGENTS: 2.21 (grams)  
MOISTURE CONTENT, B<sub>wo</sub>: 0.197
- 9) MOLECULAR WEIGHT OF GAS:  
30.4 DRY BASIS (lb<sub>m</sub>/lb mole)  
28.0 WET BASIS (lb<sub>m</sub>/lb mole)
- 10) VOLUME OF GAS SAMPLED: 70.19 (acf)
- 11) AVERAGE STACK VELOCITY: 36.52 (ft/s) AVG. TEMP: 1138(°F)  
AVERAGE VOLUMETRIC FLOW RATE: 134268 (acfm)

TABLE 111.4 FIELD DATA SUMMARY SHEET

| STACK NO. | TEST NO. | TRAVERSE NO. | TIME (MIN) | STACK TEMP (DEG F) | DELTA P (IN H2O) | VEL (FT/S) | DELTA H (IN H2O) | GAS METER VOLUME (CU FT) | PAUSE | I   | M   | P   | E   | R   | A   | I   | J   | K   | E   | S (DEG F) | GAS METER (CU FT) | PUMP VAC (IN HG) | ISOKINETIC VARIATION (PERCENT) |
|-----------|----------|--------------|------------|--------------------|------------------|------------|------------------|--------------------------|-------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----------|-------------------|------------------|--------------------------------|
| 0         | 1        | 1            | 0          | 1135               | 0.100            | 35.00      | 0.52             | 330.30                   | 450   | 450 | 150 | 150 | 150 | 150 | 150 | 150 | 150 | 150 | 150 | 150       | 150               | 150              | 0.00                           |
| 1         | 1        | 1            | 4          | 1135               | 0.100            | 35.00      | 0.52             | 337.09                   | 450   | 450 | 150 | 150 | 150 | 150 | 150 | 150 | 150 | 150 | 150 | 150       | 150               | 150              | 100.19                         |
| 2         | 1        | 1            | 8          | 1135               | 0.100            | 35.00      | 0.52             | 338.09                   | 450   | 450 | 150 | 150 | 150 | 150 | 150 | 150 | 150 | 150 | 150 | 150       | 150               | 150              | 100.80                         |
| 3         | 1        | 1            | 12         | 1135               | 0.100            | 35.00      | 0.52             | 343.15                   | 450   | 450 | 150 | 150 | 150 | 150 | 150 | 150 | 150 | 150 | 150 | 150       | 150               | 150              | 102.95                         |
| 4         | 1        | 1            | 16         | 1135               | 0.100            | 35.00      | 0.52             | 341.20                   | 450   | 450 | 150 | 150 | 150 | 150 | 150 | 150 | 150 | 150 | 150 | 150       | 150               | 150              | 94.33                          |
| 5         | 1        | 1            | 20         | 1135               | 0.100            | 35.00      | 0.52             | 342.40                   | 450   | 450 | 150 | 150 | 150 | 150 | 150 | 150 | 150 | 150 | 150 | 150       | 150               | 150              | 94.30                          |
| 6         | 1        | 1            | 24         | 1135               | 0.100            | 35.00      | 0.52             | 343.37                   | 450   | 450 | 150 | 150 | 150 | 150 | 150 | 150 | 150 | 150 | 150 | 150       | 150               | 150              | 104.34                         |
| 7         | 1        | 1            | 28         | 1135               | 0.100            | 35.00      | 0.52             | 344.95                   | 450   | 450 | 150 | 150 | 150 | 150 | 150 | 150 | 150 | 150 | 150 | 150       | 150               | 150              | 92.34                          |
| 8         | 1        | 1            | 32         | 1135               | 0.100            | 35.00      | 0.52             | 349.11                   | 450   | 450 | 150 | 150 | 150 | 150 | 150 | 150 | 150 | 150 | 150 | 150       | 150               | 150              | 100.27                         |
| 9         | 1        | 1            | 36         | 1135               | 0.100            | 35.00      | 0.52             | 348.30                   | 450   | 450 | 150 | 150 | 150 | 150 | 150 | 150 | 150 | 150 | 150 | 150       | 150               | 150              | 100.27                         |
| 10        | 1        | 1            | 40         | 1135               | 0.100            | 35.00      | 0.52             | 350.33                   | 450   | 450 | 150 | 150 | 150 | 150 | 150 | 150 | 150 | 150 | 150 | 150       | 150               | 150              | 102.29                         |
| 11        | 1        | 1            | 44         | 1135               | 0.100            | 35.00      | 0.52             | 351.13                   | 450   | 450 | 150 | 150 | 150 | 150 | 150 | 150 | 150 | 150 | 150 | 150       | 150               | 150              | 102.29                         |
| 12        | 1        | 1            | 48         | 1135               | 0.100            | 35.00      | 0.52             | 351.24                   | 450   | 450 | 150 | 150 | 150 | 150 | 150 | 150 | 150 | 150 | 150 | 150       | 150               | 150              | 102.29                         |
| 13        | 1        | 1            | 52         | 1140               | 0.100            | 35.00      | 0.52             | 353.31                   | 450   | 450 | 150 | 150 | 150 | 150 | 150 | 150 | 150 | 150 | 150 | 150       | 150               | 150              | 94.46                          |
| 14        | 1        | 1            | 56         | 1140               | 0.100            | 35.00      | 0.52             | 354.52                   | 450   | 450 | 150 | 150 | 150 | 150 | 150 | 150 | 150 | 150 | 150 | 150       | 150               | 150              | 97.07                          |
| 15        | 1        | 1            | 60         | 1140               | 0.100            | 35.00      | 0.52             | 355.33                   | 450   | 450 | 150 | 150 | 150 | 150 | 150 | 150 | 150 | 150 | 150 | 150       | 150               | 150              | 102.26                         |
| 16        | 1        | 1            | 64         | 1140               | 0.100            | 35.00      | 0.52             | 357.18                   | 450   | 450 | 150 | 150 | 150 | 150 | 150 | 150 | 150 | 150 | 150 | 150       | 150               | 150              | 102.26                         |
| 17        | 1        | 1            | 68         | 1140               | 0.100            | 35.00      | 0.52             | 359.90                   | 450   | 450 | 150 | 150 | 150 | 150 | 150 | 150 | 150 | 150 | 150 | 150       | 150               | 150              | 102.26                         |
| 18        | 1        | 1            | 72         | 1140               | 0.100            | 35.00      | 0.52             | 361.28                   | 450   | 450 | 150 | 150 | 150 | 150 | 150 | 150 | 150 | 150 | 150 | 150       | 150               | 150              | 102.26                         |
| 19        | 1        | 1            | 76         | 1140               | 0.100            | 35.00      | 0.52             | 362.66                   | 450   | 450 | 150 | 150 | 150 | 150 | 150 | 150 | 150 | 150 | 150 | 150       | 150               | 150              | 92.44                          |
| 20        | 1        | 1            | 80         | 1140               | 0.100            | 35.00      | 0.52             | 363.91                   | 450   | 450 | 150 | 150 | 150 | 150 | 150 | 150 | 150 | 150 | 150 | 150       | 150               | 150              | 98.29                          |
| 21        | 1        | 1            | 84         | 1140               | 0.100            | 35.00      | 0.52             | 365.25                   | 450   | 450 | 150 | 150 | 150 | 150 | 150 | 150 | 150 | 150 | 150 | 150       | 150               | 150              | 93.23                          |
| 22        | 1        | 1            | 88         | 1140               | 0.100            | 35.00      | 0.52             | 365.33                   | 450   | 450 | 150 | 150 | 150 | 150 | 150 | 150 | 150 | 150 | 150 | 150       | 150               | 150              | 93.23                          |
| 23        | 1        | 1            | 92         | 1140               | 0.100            | 35.00      | 0.52             | 367.80                   | 450   | 450 | 150 | 150 | 150 | 150 | 150 | 150 | 150 | 150 | 150 | 150       | 150               | 150              | 101.95                         |
| 24        | 1        | 1            | 96         | 1140               | 0.100            | 35.00      | 0.52             | 369.37                   | 450   | 450 | 150 | 150 | 150 | 150 | 150 | 150 | 150 | 150 | 150 | 150       | 150               | 150              | 104.38                         |
| 25        | 1        | 1            | 100        | 1140               | 0.100            | 35.00      | 0.52             | 370.37                   | 450   | 450 | 150 | 150 | 150 | 150 | 150 | 150 | 150 | 150 | 150 | 150       | 150               | 150              | 93.47                          |
| 26        | 1        | 1            | 104        | 1135               | 0.080            | 31.84      | 0.52             | 371.45                   | 450   | 450 | 150 | 150 | 150 | 150 | 150 | 150 | 150 | 150 | 150 | 150       | 150               | 150              | 93.47                          |
| 27        | 1        | 1            | 108        | 1135               | 0.080            | 31.84      | 0.52             | 373.00                   | 450   | 450 | 150 | 150 | 150 | 150 | 150 | 150 | 150 | 150 | 150 | 150       | 150               | 150              | 102.26                         |
| 28        | 1        | 1            | 112        | 1130               | 0.080            | 31.79      | 0.52             | 373.09                   | 450   | 450 | 150 | 150 | 150 | 150 | 150 | 150 | 150 | 150 | 150 | 150       | 150               | 150              | 97.37                          |
| 29        | 1        | 1            | 116        | 1130               | 0.080            | 31.79      | 0.52             | 373.72                   | 450   | 450 | 150 | 150 | 150 | 150 | 150 | 150 | 150 | 150 | 150 | 150       | 150               | 150              | 97.37                          |
| 30        | 1        | 1            | 120        | 1130               | 0.080            | 31.79      | 0.52             | 375.85                   | 450   | 450 | 150 | 150 | 150 | 150 | 150 | 150 | 150 | 150 | 150 | 150       | 150               | 150              | 97.37                          |
| 31        | 1        | 1            | 124        | 1130               | 0.080            | 31.79      | 0.52             | 375.85                   | 450   | 450 | 150 | 150 | 150 | 150 | 150 | 150 | 150 | 150 | 150 | 150       | 150               | 150              | 97.37                          |
| 32        | 1        | 1            | 128        | 1130               | 0.080            | 31.79      | 0.52             | 375.85                   | 450   | 450 | 150 | 150 | 150 | 150 | 150 | 150 | 150 | 150 | 150 | 150       | 150               | 150              | 97.37                          |

Table 111.5: Field Sampling Data for Test #1  
Canadian Superior-Harmattan, June 24, 1983  
Traverse #1



STACK NO. 1 TEST NO. 1 TRAVERSE NO. 2

| SAMPLE<br>POINT<br>(NO.) | TIME<br>(MIN) | STACK<br>TEMP<br>DEG.F | DELTA P<br>(IN H2O) | VEL<br>(FT/S) | DELTA H<br>(IN H2O) | GAS METER<br>VOLUME<br>(CUFT) | PROBE | TEMP<br>OVER | WATER<br>OUTLET | AIR<br>OUTLET | IMPINGERS<br>INLET | U M E<br>INLET | S (DEG.F)<br>GAS METER | PUMP<br>VAC<br>(IN HG) | ISKINETIC<br>VARIATION<br>(PERCENT) |
|--------------------------|---------------|------------------------|---------------------|---------------|---------------------|-------------------------------|-------|--------------|-----------------|---------------|--------------------|----------------|------------------------|------------------------|-------------------------------------|
| 0                        | 0             | 1140                   | 0.030               | 31.39         | 0.00                | 970.45                        | 450   | 205          |                 |               | 60                 | 120            | 83                     | 3.50                   | 0.00                                |
| 1                        | 0             | 1140                   | 0.030               | 31.39         | 0.00                | 977.65                        | 450   | 215          |                 |               | 60                 | 120            | 83                     | 3.50                   | 95.97                               |
| 2                        | 0             | 1140                   | 0.030               | 31.39         | 0.00                | 979.45                        | 450   | 230          |                 |               | 60                 | 130            | 83                     | 3.50                   | 95.00                               |
| 3                        | 12            | 1140                   | 0.100               | 32.06         | 0.02                | 979.42                        | 450   | 250          |                 |               | 60                 | 130            | 83                     | 3.50                   | 105.32                              |
| 4                        | 15            | 1140                   | 0.100               | 32.06         | 0.02                | 983.28                        | 450   | 250          |                 |               | 60                 | 135            | 83                     | 3.50                   | 95.05                               |
| 5                        | 18            | 1140                   | 0.100               | 32.06         | 0.02                | 981.14                        | 450   | 250          |                 |               | 60                 | 135            | 83                     | 3.50                   | 95.05                               |
| 6                        | 21            | 1140                   | 0.100               | 32.06         | 0.02                | 982.11                        | 450   | 250          |                 |               | 60                 | 135            | 83                     | 3.50                   | 105.19                              |
| 7                        | 24            | 1140                   | 0.100               | 32.06         | 0.02                | 983.30                        | 450   | 250          |                 |               | 60                 | 135            | 83                     | 3.50                   | 105.74                              |
| 8                        | 27            | 1140                   | 0.100               | 32.06         | 0.02                | 983.17                        | 450   | 250          |                 |               | 60                 | 135            | 83                     | 3.50                   | 95.34                               |
| 9                        | 30            | 1140                   | 0.100               | 32.06         | 0.02                | 985.75                        | 450   | 250          |                 |               | 60                 | 135            | 83                     | 3.50                   | 105.27                              |
| 10                       | 33            | 1140                   | 0.100               | 32.06         | 0.02                | 986.75                        | 450   | 250          |                 |               | 60                 | 135            | 83                     | 3.50                   | 95.92                               |
| 11                       | 36            | 1140                   | 0.100               | 32.06         | 0.02                | 987.03                        | 450   | 250          |                 |               | 60                 | 135            | 83                     | 3.50                   | 105.13                              |
| 12                       | 39            | 1140                   | 0.100               | 32.06         | 0.02                | 988.95                        | 450   | 250          |                 |               | 60                 | 140            | 83                     | 3.50                   | 95.42                               |
| 13                       | 42            | 1140                   | 0.100               | 32.06         | 0.02                | 989.45                        | 450   | 250          |                 |               | 60                 | 140            | 83                     | 3.50                   | 95.14                               |
| 14                       | 45            | 1140                   | 0.100               | 32.06         | 0.02                | 990.37                        | 450   | 250          |                 |               | 60                 | 140            | 83                     | 3.50                   | 95.14                               |
| 15                       | 48            | 1140                   | 0.100               | 32.06         | 0.02                | 991.20                        | 450   | 250          |                 |               | 60                 | 140            | 83                     | 3.50                   | 105.17                              |
| 16                       | 51            | 1140                   | 0.100               | 32.06         | 0.02                | 993.37                        | 450   | 250          |                 |               | 60                 | 145            | 83                     | 3.50                   | 105.18                              |
| 17                       | 54            | 1140                   | 0.100               | 32.06         | 0.02                | 994.04                        | 450   | 250          |                 |               | 60                 | 145            | 83                     | 3.50                   | 105.18                              |
| 18                       | 57            | 1140                   | 0.100               | 32.06         | 0.02                | 995.88                        | 450   | 250          |                 |               | 60                 | 145            | 83                     | 3.50                   | 95.70                               |
| 19                       | 60            | 1140                   | 0.100               | 32.06         | 0.02                | 996.85                        | 450   | 250          |                 |               | 60                 | 145            | 83                     | 3.50                   | 95.63                               |
| 20                       | 63            | 1140                   | 0.100               | 32.06         | 0.02                | 997.84                        | 450   | 250          |                 |               | 60                 | 145            | 83                     | 3.50                   | 95.15                               |
| 21                       | 66            | 1140                   | 0.100               | 32.06         | 0.02                | 998.82                        | 450   | 250          |                 |               | 60                 | 145            | 83                     | 3.50                   | 95.15                               |
| 22                       | 69            | 1140                   | 0.100               | 32.06         | 0.02                | 999.78                        | 450   | 250          |                 |               | 60                 | 145            | 83                     | 3.50                   | 105.15                              |
| 23                       | 72            | 1140                   | 0.100               | 32.06         | 0.02                | 1000.81                       | 450   | 250          |                 |               | 60                 | 150            | 83                     | 3.50                   | 105.15                              |
| 24                       | 75            | 1140                   | 0.100               | 32.06         | 0.02                | 1001.75                       | 450   | 250          |                 |               | 60                 | 150            | 83                     | 3.50                   | 105.15                              |
| 25                       | 78            | 1140                   | 0.100               | 32.06         | 0.02                | 1002.82                       | 450   | 250          |                 |               | 60                 | 150            | 83                     | 3.50                   | 105.15                              |
| 26                       | 81            | 1140                   | 0.100               | 32.06         | 0.02                | 1003.80                       | 450   | 250          |                 |               | 60                 | 150            | 83                     | 3.50                   | 105.15                              |
| 27                       | 84            | 1140                   | 0.100               | 32.06         | 0.02                | 1004.84                       | 450   | 250          |                 |               | 60                 | 150            | 83                     | 3.50                   | 105.15                              |
| 28                       | 87            | 1140                   | 0.100               | 32.06         | 0.02                | 1005.84                       | 450   | 250          |                 |               | 60                 | 150            | 83                     | 3.50                   | 105.15                              |
| 29                       | 90            | 1140                   | 0.100               | 32.06         | 0.02                | 1006.89                       | 450   | 250          |                 |               | 60                 | 150            | 83                     | 3.50                   | 105.15                              |
| 30                       | 93            | 1140                   | 0.100               | 32.06         | 0.02                |                               | 450   | 250          |                 |               | 60                 | 150            | 83                     | 3.50                   | 105.15                              |
| 31                       | 96            | 1140                   | 0.100               | 32.06         | 0.02                |                               | 450   | 250          |                 |               | 60                 | 150            | 83                     | 3.50                   | 105.15                              |

Table 111.6: Field Sampling Data for Test #1  
Canadian Superior-Harmattan, June 24, 1983  
Traverse #2



| Sample Analysis        | Test No 1 | Date June 24, 1983 |          | Harmattan Maximum Possible           |                                                     |
|------------------------|-----------|--------------------|----------|--------------------------------------|-----------------------------------------------------|
|                        |           | Micrograms         | Filter   | Total Elemental Weight $\mu\text{g}$ | Elemental Concentration $\mu\text{g}/\text{ref}$    |
| Sample From            | PCW       | IMP. 1.2.3.        | IMP. 4.5 |                                      | Elemental Emission Rate gm/hr                       |
| Volume (ml)            | 550.      | 1370.              | 410.     |                                      | $E_g = 6.4 \times 10^{-4} \text{ kg/g (total)}$     |
| Total Particulate (mg) | 46.39     | 80062.             | —        | 14.34                                | $E_g = 4.5 \times 10^{-3} \text{ kg/g (front end)}$ |
| Cr Chromium            | 28.0      | 76.0               | 25.0     | 20.0                                 | 2.4                                                 |
| Fe Iron                | 110.      | 710.               | 1500     | 30.0                                 | 39.                                                 |
| Mn Manganese           | 5.5       | 25.0               | 4.1      | 5.0                                  | 0.64                                                |
| Ni Nickel              | 28.0      | 64.0               | 25.0     | 20.0                                 | 2.3                                                 |
| Zn Zinc                | 52.0      | 41.0               | 74.0     | 3.0                                  | 2.7                                                 |

All elements except those in boxes ☐ are below the limit of detection.

Table 111.7: Summary of Incinerator Stack Source Sampling Data for Elements Whose Presence was Detected at the Canadian Superior-Harmattan Plant Test #1

- 1) CLIENT NAME: ENERGY RESOURCES CONSERVATION BOARD  
LOCATION: Harmattan  
COMPANY: Canadian Superior Oil Ltd.
- 2) TEST NO: 2 DATE: June 25, 1983
- 3) PRODUCTION: 3.75 MCF/d Sales Gas
- 4) BAROMETRIC PRESSURE: 26.34 (inches Hg)  
STATIC PRESSURE: -1.3 (inches H<sub>2</sub>O)  
STACK DIMENSIONS: DIAMETER (D) 8-5/6 (feet)
- 5) PITOT TUBE COEFFICIENT: 0.895  
METER CORRECTION FACTOR: 1.0  
NOZZLE DIAMETER: 0.3125 (inches)
- 6) GAS COMPOSITION: (percent by volume)  
CO<sub>2</sub> 11.56, O<sub>2</sub> 8.68, CO 0.0  
SO<sub>2</sub> 0.43, N<sub>2</sub> 78.41, Ar 0.93
- 7) NO. OF READINGS: 64  
TIME BETWEEN READINGS: 3.0 min.  
TEST POINTS/TRVERSE: 16  
NO. OF TRAVERSES: 2
- 8) CONDENSED WATER: 251.16 (grams)  
WATER CAUGHT BY DRYING AGENTS: 5.46 (grams)  
MOISTURE CONTENT, B<sub>WO</sub>: 0.184
- 9) MOLECULAR WEIGHT OF GAS:  
30.4 DRY BASIS (lb<sub>m</sub>/lb mole)  
28.2 WET BASIS (lb<sub>m</sub>/lb mole)
- 10) VOLUME OF GAS SAMPLED: 63.24 (acf)
- 11) AVERAGE STACK VELOCITY: 37.15 (ft/s) AVG. TEMP: 1140(°F)  
AVERAGE VOLUMETRIC FLOW RATE: 136580 (acfm)

TABLE 111.8 FIELD DATA SUMMARY SHEET

| STACK NO.               | TEST NO.      | 2                        | TRAVERSE NO.        | 1               |                     |                                |       |                 |             |             |             |             |             |             |               |             |                        |                                     |
|-------------------------|---------------|--------------------------|---------------------|-----------------|---------------------|--------------------------------|-------|-----------------|-------------|-------------|-------------|-------------|-------------|-------------|---------------|-------------|------------------------|-------------------------------------|
| SAMPLE<br>POINT<br>(IN) | TIME<br>(MIN) | STACK<br>TEMP<br>(DEG F) | DELTA P<br>(IN H2O) | VEL<br>(FT/SEC) | DELTA H<br>(IN H2O) | GAS METER<br>VOLUME<br>(CU FT) | PROBE | TEMP<br>(DEG F) | W<br>OUTLET | A<br>IMPERF | Y<br>IMPERF | U<br>IMPERF | N<br>IMPERF | E<br>IMPERF | JAS<br>IMPERF | W<br>IMPERF | PUMP<br>VAC<br>(IN HG) | ISOMETRIC<br>VARIATION<br>(PERCENT) |
| 0                       | 0             | 1140                     | 0.100               | 35.55           | 0.31                | 78.09                          | 450   | 450             | 100         | 60          | 60          | 60          | 60          | 60          | 60            | 60          | 4.00                   | 96.34                               |
| 1                       | 3             | 1140                     | 0.100               | 35.55           | 0.31                | 78.99                          | 450   | 450             | 100         | 60          | 60          | 60          | 60          | 60          | 60            | 60          | 4.00                   | 100.51                              |
| 2                       | 6             | 1140                     | 0.100               | 35.55           | 0.32                | 79.94                          | 450   | 450             | 100         | 60          | 60          | 60          | 60          | 60          | 60            | 60          | 4.00                   | 104.03                              |
| 3                       | 9             | 1140                     | 0.100               | 35.55           | 0.32                | 80.92                          | 450   | 450             | 100         | 60          | 60          | 60          | 60          | 60          | 60            | 60          | 4.00                   | 107.57                              |
| 4                       | 12            | 1140                     | 0.100               | 35.55           | 0.32                | 81.90                          | 450   | 450             | 100         | 60          | 60          | 60          | 60          | 60          | 60            | 60          | 4.00                   | 111.10                              |
| 5                       | 15            | 1140                     | 0.100               | 35.55           | 0.32                | 82.88                          | 450   | 450             | 100         | 60          | 60          | 60          | 60          | 60          | 60            | 60          | 4.00                   | 114.64                              |
| 6                       | 18            | 1140                     | 0.100               | 35.55           | 0.32                | 83.86                          | 450   | 450             | 100         | 60          | 60          | 60          | 60          | 60          | 60            | 60          | 4.00                   | 118.18                              |
| 7                       | 21            | 1140                     | 0.100               | 35.55           | 0.32                | 84.84                          | 450   | 450             | 100         | 60          | 60          | 60          | 60          | 60          | 60            | 60          | 4.00                   | 121.72                              |
| 8                       | 24            | 1140                     | 0.100               | 35.55           | 0.32                | 85.82                          | 450   | 450             | 100         | 60          | 60          | 60          | 60          | 60          | 60            | 60          | 4.00                   | 125.26                              |
| 9                       | 27            | 1140                     | 0.100               | 35.55           | 0.32                | 86.80                          | 450   | 450             | 100         | 60          | 60          | 60          | 60          | 60          | 60            | 60          | 4.00                   | 128.80                              |
| 10                      | 30            | 1140                     | 0.120               | 38.95           | 0.39                | 88.78                          | 450   | 450             | 100         | 60          | 60          | 60          | 60          | 60          | 60            | 60          | 4.50                   | 132.34                              |
| 11                      | 33            | 1140                     | 0.120               | 38.95           | 0.39                | 89.76                          | 450   | 450             | 100         | 60          | 60          | 60          | 60          | 60          | 60            | 60          | 4.50                   | 135.88                              |
| 12                      | 36            | 1140                     | 0.120               | 38.95           | 0.39                | 90.72                          | 450   | 450             | 100         | 60          | 60          | 60          | 60          | 60          | 60            | 60          | 4.50                   | 139.42                              |
| 13                      | 39            | 1140                     | 0.120               | 38.95           | 0.39                | 91.68                          | 450   | 450             | 100         | 60          | 60          | 60          | 60          | 60          | 60            | 60          | 4.50                   | 142.96                              |
| 14                      | 42            | 1140                     | 0.120               | 38.95           | 0.39                | 92.64                          | 450   | 450             | 100         | 60          | 60          | 60          | 60          | 60          | 60            | 60          | 4.50                   | 146.50                              |
| 15                      | 45            | 1140                     | 0.120               | 38.95           | 0.39                | 93.60                          | 450   | 450             | 100         | 60          | 60          | 60          | 60          | 60          | 60            | 60          | 4.50                   | 150.04                              |
| 16                      | 48            | 1140                     | 0.120               | 38.95           | 0.39                | 94.56                          | 450   | 450             | 100         | 60          | 60          | 60          | 60          | 60          | 60            | 60          | 4.50                   | 153.58                              |
| 17                      | 51            | 1140                     | 0.120               | 38.95           | 0.39                | 95.52                          | 450   | 450             | 100         | 60          | 60          | 60          | 60          | 60          | 60            | 60          | 4.50                   | 157.12                              |
| 18                      | 54            | 1140                     | 0.120               | 38.95           | 0.39                | 96.48                          | 450   | 450             | 100         | 60          | 60          | 60          | 60          | 60          | 60            | 60          | 4.50                   | 160.66                              |
| 19                      | 57            | 1140                     | 0.120               | 38.95           | 0.39                | 97.44                          | 450   | 450             | 100         | 60          | 60          | 60          | 60          | 60          | 60            | 60          | 4.50                   | 164.20                              |
| 20                      | 60            | 1140                     | 0.120               | 38.95           | 0.39                | 98.40                          | 450   | 450             | 100         | 60          | 60          | 60          | 60          | 60          | 60            | 60          | 4.50                   | 167.74                              |
| 21                      | 63            | 1140                     | 0.120               | 38.95           | 0.39                | 99.36                          | 450   | 450             | 100         | 60          | 60          | 60          | 60          | 60          | 60            | 60          | 4.50                   | 171.28                              |
| 22                      | 66            | 1140                     | 0.120               | 38.95           | 0.39                | 100.32                         | 450   | 450             | 100         | 60          | 60          | 60          | 60          | 60          | 60            | 60          | 4.50                   | 174.82                              |
| 23                      | 69            | 1140                     | 0.120               | 38.95           | 0.39                | 101.28                         | 450   | 450             | 100         | 60          | 60          | 60          | 60          | 60          | 60            | 60          | 4.50                   | 178.36                              |
| 24                      | 72            | 1140                     | 0.120               | 38.95           | 0.39                | 102.24                         | 450   | 450             | 100         | 60          | 60          | 60          | 60          | 60          | 60            | 60          | 4.50                   | 181.90                              |
| 25                      | 75            | 1140                     | 0.100               | 35.55           | 0.33                | 103.19                         | 450   | 450             | 100         | 60          | 60          | 60          | 60          | 60          | 60            | 60          | 4.00                   | 185.44                              |
| 26                      | 78            | 1140                     | 0.100               | 35.55           | 0.33                | 104.15                         | 450   | 450             | 100         | 60          | 60          | 60          | 60          | 60          | 60            | 60          | 4.00                   | 188.98                              |
| 27                      | 81            | 1140                     | 0.100               | 35.55           | 0.33                | 105.11                         | 450   | 450             | 100         | 60          | 60          | 60          | 60          | 60          | 60            | 60          | 4.00                   | 192.52                              |
| 28                      | 84            | 1140                     | 0.100               | 35.55           | 0.33                | 106.07                         | 450   | 450             | 100         | 60          | 60          | 60          | 60          | 60          | 60            | 60          | 4.00                   | 196.06                              |
| 29                      | 87            | 1140                     | 0.100               | 35.55           | 0.33                | 107.03                         | 450   | 450             | 100         | 60          | 60          | 60          | 60          | 60          | 60            | 60          | 4.00                   | 199.60                              |
| 30                      | 90            | 1140                     | 0.100               | 35.55           | 0.33                | 107.99                         | 450   | 450             | 100         | 60          | 60          | 60          | 60          | 60          | 60            | 60          | 4.00                   | 203.14                              |
| 31                      | 93            | 1140                     | 0.100               | 35.55           | 0.33                | 108.95                         | 450   | 450             | 100         | 60          | 60          | 60          | 60          | 60          | 60            | 60          | 4.00                   | 206.68                              |
| 32                      | 96            | 1140                     | 0.100               | 35.55           | 0.33                | 109.91                         | 450   | 450             | 100         | 60          | 60          | 60          | 60          | 60          | 60            | 60          | 4.00                   | 210.22                              |

Table 111.9: Field Sampling Data for Test #2  
Canadian Superior-Harmattan, June 25, 1983  
Traverse #1

| STACK NO.               | 1             | TEST NO.               | 2                   | TRAVERSE NO.  | 3                   |                         |            |       |              |              |            |            |            |       |                        |                                      |
|-------------------------|---------------|------------------------|---------------------|---------------|---------------------|-------------------------|------------|-------|--------------|--------------|------------|------------|------------|-------|------------------------|--------------------------------------|
| SAMPLE<br>POINT<br>(NO) | TIME<br>(MIN) | STACK<br>TEMP<br>DEG F | DELTA P<br>(IN H2O) | VEL<br>(FT/S) | DELTA H<br>(IN H2O) | GAS<br>VALUE<br>(CU FT) | PIQUE<br>I | OVERH | WET<br>INLET | IMP<br>INLET | U<br>INLET | V<br>INLET | GAS<br>OUT | DEG F | PUMP<br>VAC<br>(IN HG) | ISOTHERMIC<br>VARIATION<br>(PERCENT) |
| 0                       | 3             | 110                    | 0.120               | 38.95         | 0.98                | 10.17                   | 450        | 195   | 55           | 55           | 10         | 85         | 85         | 85    | 4.50                   | 0.00                                 |
| 1                       | 6             | 110                    | 0.120               | 38.95         | 0.98                | 11.14                   | 450        | 195   | 55           | 55           | 10         | 85         | 85         | 85    | 4.50                   | 94.75                                |
| 2                       | 9             | 110                    | 0.120               | 38.95         | 0.98                | 12.12                   | 450        | 200   | 55           | 55           | 10         | 85         | 85         | 85    | 4.50                   | 95.75                                |
| 3                       | 12            | 110                    | 0.120               | 38.95         | 0.98                | 13.10                   | 450        | 215   | 55           | 55           | 10         | 85         | 85         | 85    | 4.50                   | 96.75                                |
| 4                       | 15            | 110                    | 0.120               | 38.95         | 0.98                | 14.16                   | 450        | 220   | 55           | 55           | 10         | 85         | 85         | 85    | 4.50                   | 103.75                               |
| 5                       | 18            | 110                    | 0.120               | 38.95         | 0.98                | 15.13                   | 450        | 230   | 55           | 55           | 10         | 85         | 85         | 85    | 4.50                   | 103.75                               |
| 6                       | 21            | 110                    | 0.120               | 38.95         | 0.98                | 16.10                   | 450        | 235   | 55           | 55           | 10         | 85         | 85         | 85    | 4.50                   | 103.75                               |
| 7                       | 24            | 110                    | 0.120               | 38.95         | 0.98                | 17.16                   | 450        | 240   | 55           | 55           | 10         | 85         | 85         | 85    | 4.50                   | 103.75                               |
| 8                       | 27            | 110                    | 0.120               | 38.95         | 0.98                | 18.14                   | 450        | 240   | 55           | 55           | 10         | 85         | 85         | 85    | 4.50                   | 103.75                               |
| 9                       | 30            | 110                    | 0.120               | 38.95         | 0.98                | 19.11                   | 450        | 250   | 55           | 55           | 10         | 85         | 85         | 85    | 4.50                   | 103.75                               |
| 10                      | 33            | 110                    | 0.120               | 38.95         | 0.98                | 20.11                   | 450        | 250   | 55           | 55           | 10         | 85         | 85         | 85    | 4.50                   | 103.75                               |
| 11                      | 36            | 110                    | 0.120               | 38.95         | 0.98                | 21.18                   | 450        | 250   | 55           | 55           | 10         | 85         | 85         | 85    | 4.50                   | 103.75                               |
| 12                      | 39            | 110                    | 0.120               | 38.95         | 0.98                | 22.14                   | 450        | 250   | 55           | 55           | 10         | 85         | 85         | 85    | 4.50                   | 103.75                               |
| 13                      | 42            | 110                    | 0.120               | 38.95         | 0.98                | 23.12                   | 450        | 250   | 55           | 55           | 10         | 85         | 85         | 85    | 4.50                   | 103.75                               |
| 14                      | 45            | 110                    | 0.120               | 38.95         | 0.98                | 24.12                   | 450        | 250   | 55           | 55           | 10         | 85         | 85         | 85    | 4.50                   | 103.75                               |
| 15                      | 48            | 110                    | 0.120               | 38.95         | 0.98                | 25.11                   | 450        | 250   | 55           | 55           | 10         | 85         | 85         | 85    | 4.50                   | 103.75                               |
| 16                      | 51            | 110                    | 0.120               | 38.95         | 0.98                | 26.11                   | 450        | 250   | 55           | 55           | 10         | 85         | 85         | 85    | 4.50                   | 103.75                               |
| 17                      | 54            | 110                    | 0.120               | 38.95         | 0.98                | 27.10                   | 450        | 250   | 55           | 55           | 10         | 85         | 85         | 85    | 4.50                   | 103.75                               |
| 18                      | 57            | 110                    | 0.120               | 38.95         | 0.98                | 28.10                   | 450        | 250   | 55           | 55           | 10         | 85         | 85         | 85    | 4.50                   | 103.75                               |
| 19                      | 60            | 110                    | 0.120               | 38.95         | 0.98                | 29.10                   | 450        | 250   | 55           | 55           | 10         | 85         | 85         | 85    | 4.50                   | 103.75                               |
| 20                      | 63            | 110                    | 0.120               | 38.95         | 0.98                | 30.10                   | 450        | 250   | 55           | 55           | 10         | 85         | 85         | 85    | 4.50                   | 103.75                               |
| 21                      | 66            | 110                    | 0.120               | 38.95         | 0.98                | 31.10                   | 450        | 250   | 55           | 55           | 10         | 85         | 85         | 85    | 4.50                   | 103.75                               |
| 22                      | 69            | 110                    | 0.120               | 38.95         | 0.98                | 32.10                   | 450        | 250   | 55           | 55           | 10         | 85         | 85         | 85    | 4.50                   | 103.75                               |
| 23                      | 72            | 110                    | 0.120               | 38.95         | 0.98                | 33.10                   | 450        | 250   | 55           | 55           | 10         | 85         | 85         | 85    | 4.50                   | 103.75                               |
| 24                      | 75            | 110                    | 0.120               | 38.95         | 0.98                | 34.10                   | 450        | 250   | 55           | 55           | 10         | 85         | 85         | 85    | 4.50                   | 103.75                               |
| 25                      | 78            | 110                    | 0.120               | 38.95         | 0.98                | 35.10                   | 450        | 250   | 55           | 55           | 10         | 85         | 85         | 85    | 4.50                   | 103.75                               |
| 26                      | 81            | 110                    | 0.120               | 38.95         | 0.98                | 36.10                   | 450        | 250   | 55           | 55           | 10         | 85         | 85         | 85    | 4.50                   | 103.75                               |
| 27                      | 84            | 110                    | 0.120               | 38.95         | 0.98                | 37.10                   | 450        | 250   | 55           | 55           | 10         | 85         | 85         | 85    | 4.50                   | 103.75                               |
| 28                      | 87            | 110                    | 0.120               | 38.95         | 0.98                | 38.10                   | 450        | 250   | 55           | 55           | 10         | 85         | 85         | 85    | 4.50                   | 103.75                               |
| 29                      | 90            | 110                    | 0.120               | 38.95         | 0.98                | 39.10                   | 450        | 250   | 55           | 55           | 10         | 85         | 85         | 85    | 4.50                   | 103.75                               |
| 30                      | 93            | 110                    | 0.120               | 38.95         | 0.98                | 40.10                   | 450        | 250   | 55           | 55           | 10         | 85         | 85         | 85    | 4.50                   | 103.75                               |
| 31                      | 96            | 110                    | 0.120               | 38.95         | 0.98                | 41.10                   | 450        | 250   | 55           | 55           | 10         | 85         | 85         | 85    | 4.50                   | 103.75                               |

Table 111.10: Field Sampling Data for Test #2  
Canadian Superior-Harmattan, June 25, 1983  
Traverse #2

| Sample Analytes        | Test No 2                 | Date June 25, 1983 | Harmattan                                |                                  |
|------------------------|---------------------------|--------------------|------------------------------------------|----------------------------------|
|                        |                           |                    | Maximum                                  | Possible                         |
|                        |                           |                    | Elemental Concentration<br>µg/sec        | Elemental Emission Rate<br>gm/hr |
| Sample From            | Micrograms IMP.<br>1,2,3. | IMP.<br>4.5        | Filter                                   |                                  |
| Volume (ml)            | 1275.                     | 335.               |                                          |                                  |
| Total Particulate (mg) | 50358.                    | —                  | 6.894                                    |                                  |
|                        |                           |                    | $E_g = 4.3 \times 10^4$ kg/d (total)     |                                  |
|                        |                           |                    | $E_g = 9.8 \times 10^3$ kg/d (front end) |                                  |
| As Arsenic             | 4.2                       | 6.4                | 0.67                                     | 0.5                              |
| Cu Copper              | 310.                      | 26.0               | 23.0                                     | 10.0                             |
| Fe Iron                | 47000                     | 360.               | 2700                                     | 10.0                             |
| Mn Manganese           | 190.                      | 6.4                | 10.0                                     | 5.0                              |
| Ni Nickel              | 47.0                      | 26.0               | 23.0                                     | 20.0                             |
| Zn Zinc                | 12000                     | 23.0               | 70.0                                     | 2.0                              |

All elements except those in boxes ☐ are below the limit of detection.

Table 111.11: Summary of Incinerator Stack Source Sampling Data for Elements Whose Presence was Detected at the Canadian Superior-Harmattan Plant Test #2

- 1) CLIENT NAME: ENERGY RESOURCES CONSERVATION BOARD  
LOCATION: Harmattan  
COMPANY: Canadian Superior Oil Ltd.
- 2) TEST NO: 3 DATE: June 26, 1983
- 3) PRODUCTION: 3.77 MCF/d Sales Gas
- 4) BAROMETRIC PRESSURE: 26.30 (inches Hg)  
STATIC PRESSURE: -1.4 (inches H<sub>2</sub>O)  
STACK DIMENSIONS: DIAMETER (D) 8-5/6 (feet)
- 5) PITOT TUBE COEFFICIENT: 0.895  
METER CORRECTION FACTOR: 1.0  
NOZZLE DIAMETER: 0.3125 (inches)
- 6) GAS COMPOSITION: (percent by volume)  
CO<sub>2</sub> 10.95, O<sub>2</sub> 8.71, CO 0.0  
SO<sub>2</sub> 0.37, N<sub>2</sub> 79.03, Ar 0.94
- 7) NO. OF READINGS: 64  
TIME BETWEEN READINGS: 3.0 min.  
TEST POINTS/TRVERSE: 16  
NO. OF TRAVERSES: 2
- 8) CONDENSED WATER: 259.30 (grams)  
WATER CAUGHT BY DRYING AGENTS: 5.81 (grams)  
MOISTURE CONTENT, B<sub>WO</sub>: 0.184
- 9) MOLECULAR WEIGHT OF GAS:  
30.4 DRY BASIS (lb<sub>m</sub>/lb mole)  
28.1 WET BASIS (lb<sub>m</sub>/lb mole)
- 10) VOLUME OF GAS SAMPLED: 63.61 (acf)
- 11) AVERAGE STACK VELOCITY: 37.88 (ft/s) AVG. TEMP: 1140(°F)  
AVERAGE VOLUMETRIC FLOW RATE: 139288 (acfm)

TABLE 111.12 FIELD DATA SUMMARY SHEET



| STACK NO. I               |               | TEST NO. J             |                     | TRAVERSE NO. I |                     | T E A P E R A                 |       | I U R E S (JUMP) |             | PUMP                          |    | ISOKINETIC     |         |
|---------------------------|---------------|------------------------|---------------------|----------------|---------------------|-------------------------------|-------|------------------|-------------|-------------------------------|----|----------------|---------|
| SAMPLE<br>SACINT<br>(NO.) | TIME<br>(MIN) | STACK<br>TEMP<br>DEG F | DELTA P<br>(IN H2O) | VEL<br>(FT/S)  | DELTA H<br>(IN H2O) | GAS METLN<br>VOLUME<br>(CUFT) | P-COE | J VCH            | OUTLET TIME | GAS METLN<br>VOLUME<br>(CUFT) | IN | VAC<br>(IN HG) | PERCENT |
| 0                         | 0             | 1135                   | 0.120               | 38.50          | 0.99                | 193.11                        | 450   | 143              | 70          | 95                            | 80 | 4.50           | 0.00    |
| 1                         | 3             | 1135                   | 0.123               | 38.90          | 0.98                | 194.37                        | 450   | 143              | 70          | 95                            | 80 | 4.50           | 42.77   |
| 2                         | 9             | 1140                   | 0.120               | 39.32          | 0.98                | 195.32                        | 450   | 145              | 70          | 95                            | 80 | 4.50           | 105.33  |
| 3                         | 12            | 1140                   | 0.120               | 39.32          | 0.98                | 197.17                        | 450   | 203              | 70          | 95                            | 80 | 4.50           | 104.25  |
| 4                         | 15            | 1140                   | 0.120               | 39.32          | 0.98                | 197.53                        | 450   | 210              | 70          | 95                            | 80 | 4.50           | 104.14  |
| 5                         | 18            | 1140                   | 0.123               | 39.32          | 0.98                | 198.58                        | 450   | 223              | 70          | 95                            | 80 | 4.50           | 102.52  |
| 6                         | 21            | 1140                   | 0.123               | 39.32          | 0.98                | 201.24                        | 450   | 223              | 70          | 95                            | 80 | 4.50           | 94.41   |
| 7                         | 24            | 1140                   | 0.123               | 39.32          | 0.98                | 201.24                        | 450   | 230              | 70          | 95                            | 80 | 4.50           | 100.39  |
| 8                         | 27            | 1140                   | 0.120               | 39.32          | 0.97                | 202.41                        | 450   | 230              | 70          | 95                            | 80 | 4.50           | 95.52   |
| 9                         | 30            | 1140                   | 0.120               | 39.32          | 0.97                | 203.41                        | 450   | 235              | 70          | 95                            | 80 | 4.50           | 107.74  |
| 10                        | 33            | 1140                   | 0.120               | 39.32          | 0.97                | 204.48                        | 450   | 240              | 70          | 95                            | 80 | 4.50           | 107.32  |
| 11                        | 36            | 1140                   | 0.120               | 39.32          | 0.97                | 205.48                        | 450   | 250              | 70          | 95                            | 80 | 4.50           | 96.34   |
| 12                        | 39            | 1140                   | 0.120               | 39.32          | 0.97                | 206.45                        | 450   | 250              | 70          | 95                            | 80 | 4.50           | 96.34   |
| 13                        | 42            | 1140                   | 0.120               | 39.32          | 0.97                | 207.44                        | 450   | 260              | 70          | 95                            | 80 | 4.50           | 100.42  |
| 14                        | 45            | 1140                   | 0.120               | 39.32          | 0.97                | 209.55                        | 450   | 270              | 70          | 95                            | 80 | 4.50           | 103.34  |
| 15                        | 48            | 1140                   | 0.120               | 39.32          | 0.97                | 210.00                        | 450   | 260              | 70          | 95                            | 80 | 4.50           | 103.34  |
| 16                        | 51            | 1140                   | 0.120               | 39.32          | 0.96                | 211.64                        | 450   | 260              | 70          | 95                            | 80 | 4.50           | 98.98   |
| 17                        | 54            | 1140                   | 0.120               | 39.32          | 0.96                | 212.54                        | 450   | 260              | 70          | 95                            | 80 | 4.50           | 98.17   |
| 18                        | 57            | 1140                   | 0.120               | 39.32          | 0.96                | 213.63                        | 450   | 260              | 70          | 95                            | 80 | 4.50           | 98.16   |
| 19                        | 60            | 1140                   | 0.120               | 39.32          | 0.96                | 214.62                        | 450   | 250              | 70          | 95                            | 80 | 4.50           | 101.16  |
| 20                        | 63            | 1140                   | 0.100               | 35.62          | 0.81                | 215.00                        | 450   | 250              | 70          | 95                            | 80 | 4.50           | 101.02  |
| 21                        | 66            | 1140                   | 0.100               | 35.62          | 0.81                | 216.34                        | 450   | 250              | 70          | 95                            | 80 | 4.50           | 101.02  |
| 22                        | 69            | 1140                   | 0.100               | 35.62          | 0.81                | 217.31                        | 450   | 250              | 70          | 95                            | 80 | 4.50           | 101.58  |
| 23                        | 72            | 1140                   | 0.100               | 35.62          | 0.81                | 218.31                        | 450   | 250              | 70          | 95                            | 80 | 4.50           | 101.58  |
| 24                        | 75            | 1140                   | 0.100               | 35.62          | 0.81                | 219.40                        | 450   | 250              | 70          | 95                            | 80 | 4.50           | 101.58  |
| 25                        | 78            | 1140                   | 0.100               | 35.62          | 0.81                | 220.40                        | 450   | 250              | 70          | 95                            | 80 | 4.50           | 101.58  |
| 26                        | 81            | 1140                   | 0.100               | 35.62          | 0.81                | 221.44                        | 450   | 250              | 70          | 95                            | 80 | 4.50           | 101.58  |
| 27                        | 84            | 1140                   | 0.120               | 39.32          | 0.97                | 222.38                        | 450   | 260              | 70          | 95                            | 80 | 4.50           | 101.58  |
| 28                        | 87            | 1140                   | 0.120               | 39.32          | 0.97                | 223.38                        | 450   | 260              | 70          | 95                            | 80 | 4.50           | 101.58  |
| 29                        | 90            | 1140                   | 0.120               | 39.32          | 0.97                | 224.38                        | 450   | 260              | 70          | 95                            | 80 | 4.50           | 101.58  |
| 30                        | 93            | 1140                   | 0.120               | 39.32          | 0.97                | 225.38                        | 450   | 260              | 70          | 95                            | 80 | 4.50           | 101.58  |
| 31                        | 96            | 1140                   | 0.120               | 39.32          | 0.97                | 226.38                        | 450   | 260              | 70          | 95                            | 80 | 4.50           | 101.58  |

Table 111.13: Field Sampling Data for Test #3  
Canadian Superior-Harmattan, June 26, 1983  
Traverse #1



**Table III.14: Field Sampling Data for Test #3  
Canadian Superior-Harmattan, June 26, 1983  
Traverse #2**



- 1) CLIENT NAME: ENERGY RESOURCES CONSERVATION BOARD  
LOCATION: Nevis  
COMPANY: Gulf Canada
- 2) TEST NO: Prelim      DATE: June 27, 1983
- 3) PRODUCTION: Not Recorded
- 4) BAROMETRIC PRESSURE: 27.38      (inches Hg)  
STATIC PRESSURE: -1.5      (inches H<sub>2</sub>O)  
STACK DIMENSIONS: DIAMETER (D) 4      (feet)
- 5) PITOT TUBE COEFFICIENT: 0.795  
METER CORRECTION FACTOR: 1.0  
NOZZLE DIAMETER: 0.3125      (inches)
- 6) GAS COMPOSITION: (percent by volume)  
CO<sub>2</sub> 11.33,      O<sub>2</sub> 10.31,      CO 0.0  
SO<sub>2</sub> 0.32,      N<sub>2</sub> 77.11,      Ar 0.93
- 7) NO. OF READINGS: 48  
TIME BETWEEN READINGS: <sup>I</sup> 2.5      <sup>II</sup> 3.0 min.  
TEST POINTS/TRVERSE: 12  
NO. OF TRAVERSES: 2
- 8) CONDENSED WATER: 313.46      (grams)  
WATER CAUGHT BY DRYING AGENTS: 10.04 (grams)  
MOISTURE CONTENT, B<sub>wo</sub>: 0.156
- 9) MOLECULAR WEIGHT OF GAS:  
30.4      DRY BASIS (lb<sub>m</sub>/lb mole)  
28.5      WET BASIS (lb<sub>m</sub>/lb mole)
- 10) VOLUME OF GAS SAMPLED: 91.38      (acf)
- 11) AVERAGE STACK VELOCITY: 66.68      (ft/s) AVG. TEMP: 924 (°F)  
AVERAGE VOLUMETRIC FLOW RATE: 50293      (acfm)

TABLE 111.16 FIELD DATA SUMMARY SHEET





- 1) CLIENT NAME: ENERGY RESOURCES CONSERVATION BOARD  
LOCATION: Nevis  
COMPANY: Gulf Canada
- 2) TEST NO: 1 DATE: June 28, 1983
- 3) PRODUCTION: Not Recorded
- 4) BAROMETRIC PRESSURE: 27.32 (inches Hg)  
STATIC PRESSURE: -1.75 (inches H<sub>2</sub>O)  
STACK DIMENSIONS: DIAMETER (D) 4 (feet)
- 5) PITOT TUBE COEFFICIENT: 0.795  
METER CORRECTION FACTOR: 1.0  
NOZZLE DIAMETER: 0.3125 (inches)
- 6) GAS COMPOSITION: (percent by volume)  
CO<sub>2</sub> 11.33, O<sub>2</sub> 10.31, CO 0.0  
SO<sub>2</sub> 0.32, N<sub>2</sub> 77.12, Ar 0.92
- 7) NO. OF READINGS: 48  
TIME BETWEEN READINGS: 3 min.  
TEST POINTS/TRVERSE: 12  
NO. OF TRAVERSES: 2
- 8) CONDENSED WATER: 329.26 (grams)  
WATER CAUGHT BY DRYING AGENTS: 12.40 (grams)  
MOISTURE CONTENT, B<sub>WO</sub>: 0.168
- 9) MOLECULAR WEIGHT OF GAS;  
30.5 DRY BASIS (lb<sub>m</sub>/lb mole)  
28.4 WET BASIS (lb<sub>m</sub>/lb mole)
- 10) VOLUME OF GAS SAMPLED: 89.03 (acf)
- 11) AVERAGE STACK VELOCITY: 61.76 (ft/s) AVG. TEMP: 925 (°F)  
AVERAGE VOLUMETRIC FLOW RATE: 46 579 (acfm)

TABLE 111.19 FIELD DATA SUMMARY SHEET









| Sample Analysis        | Test No | 1          | Date   | June 28, 1983 | Nevis                                    |               |           |
|------------------------|---------|------------|--------|---------------|------------------------------------------|---------------|-----------|
|                        |         |            |        |               | Maximum Possible                         | Elemental     | Elemental |
|                        |         |            |        |               | Concentration                            | Concentration | Emission  |
|                        |         |            |        |               | µg/scf                                   | µg/scf        | gm/hr     |
| Sample From            | PM      | Micrograms | Imp.   | Filter        | Total Elemental Weight µg                |               |           |
|                        |         | Imp.       | 1,2,3. | 4.5           |                                          |               |           |
| Volume (all)           | 470.    | 1100       | 470.   |               |                                          |               |           |
| Total Particulate (mg) | 45.44   | 56994.     | —      | 21.88         |                                          |               |           |
|                        |         |            |        |               | $E_p = 1.6 \times 10^4$ kg/d (total)     |               |           |
|                        |         |            |        |               | $E_p = 1.6 \times 10^3$ kg/d (front end) |               |           |
| Aluminum               | 140.    | 110.       | 4200   | 50.0          | 4500                                     | 55.           | 45.       |
| As Arsenic             | 0.094   | 0.55       | 4.0    | 0.5           | 6.0                                      | 0.07          | 0.04      |
| Fe Iron                | 280.    | 660        | 710    | 10.0          | 1700                                     | 21.           | 17.       |
| Zn Zinc                | 61.0    | 63.0       | 89.0   | 1.0           | 220                                      | 2.7           | 2.2       |

All elements except those in boxes ☐ are below the limit of detection.

Table 111.22: Summary of Incinerator Stack Source Sampling Data for Elements Whose Presence was Detected at the Gulf-Nevis Plant, Test #1

- 1) CLIENT NAME: ENERGY RESOURCES CONSERVATION BOARD  
LOCATION: Nevis  
COMPANY: Gulf Canada
- 2) TEST NO: 2 DATE: June 29, 1983
- 3) PRODUCTION: Not Recorded
- 4) BAROMETRIC PRESSURE: 27.19 (inches Hg)  
STATIC PRESSURE: -1.75 (inches H<sub>2</sub>O)  
STACK DIMENSIONS: DIAMETER (D) 4 (feet)
- 5) PITOT TUBE COEFFICIENT: 0.795  
METER CORRECTION FACTOR: 1.0  
NOZZLE DIAMETER: 0.3125 (inches)
- 6) GAS COMPOSITION: (percent by volume)  
CO<sub>2</sub> 10.45, O<sub>2</sub> 10.50, CO 0.0  
SO<sub>2</sub> 0.32, N<sub>2</sub> 77.81, Ar 0.92
- 7) NO. OF READINGS: 48  
TIME BETWEEN READINGS: 4.0 min.  
TEST POINTS/TRVERSE: 12  
NO. OF TRAVERSES: 2
- 8) CONDENSED WATER: 420.25 (grams)  
WATER CAUGHT BY DRYING AGENTS: 16.49 (grams)  
MOISTURE CONTENT, B<sub>wo</sub>: 0.168
- 9) MOLECULAR WEIGHT OF GAS:  
30.3 DRY BASIS (lb<sub>m</sub>/lb mole)  
28.3 WET BASIS (lb<sub>m</sub>/lb mole)
- 10) VOLUME OF GAS SAMPLED: 114.76 (acf)
- 11) AVERAGE STACK VELOCITY: 57.38 (ft/s) AVG. TEMP: 926 (°F)  
AVERAGE VOLUMETRIC FLOW RATE: 43274 (acfm)

TABLE 111.23 FIELD DATA SUMMARY SHEET





| Sample Analysis        | Test No 2   | Date     | June 29, 1983 | Nevis Maximum Possible                   |
|------------------------|-------------|----------|---------------|------------------------------------------|
|                        | Micrograms  |          |               |                                          |
| Sample From            | IMP. 1,2,3. | IMP. 4,5 | Filter        | Total Elemental Weight pg                |
| Volume (ml)            | 330.        | 1150     | 265           | $E_g = 6.4 \times 10^3$ kg/d (total)     |
| Total Particulate (mg) | 43.61       | 16626.   | —             | $E_g = 1.1 \times 10^1$ kg/d (front end) |
| Aluminum               | 330.        | 120.     | 130.          | 50.0                                     |
| Fe Iron                | 200.        | 170.     | 240.          | 20.0                                     |
| Mn Manganese           | 3.9         | 8.1      | 3.0           | 5.0                                      |
| Zn Zinc                | 46.0        | 110.     | 82.0          | 1.0                                      |
|                        |             |          |               | 6.1                                      |
|                        |             |          |               | 6.1                                      |
|                        |             |          |               | 0.30                                     |
|                        |             |          |               | 2.3                                      |
|                        |             |          |               | 4.6                                      |
|                        |             |          |               | 4.6                                      |
|                        |             |          |               | 0.23                                     |
|                        |             |          |               | 1.8                                      |

All elements except those in boxes ☐ are below the limit of detection.

Table 111.26: Summary of Incinerator Stack Source Sampling Data for Elements Whose Presence was Detected at the Gulf-Nevis Plant, Test #2



- 1) CLIENT NAME: ENERGY RESOURCES CONSERVATION BOARD  
LOCATION: Nevis  
COMPANY: Gulf Canada
- 2) TEST NO: 3 DATE: June 30, 1983
- 3) PRODUCTION: Not Recorded
- 4) BAROMETRIC PRESSURE: 26.99 (inches Hg)  
STATIC PRESSURE: -1.75 (inches H<sub>2</sub>O)  
STACK DIMENSIONS: DIAMETER (D) 4 (feet)
- 5) PITOT TUBE COEFFICIENT: 0.795  
METER CORRECTION FACTOR: 1.0  
NOZZLE DIAMETER: 0.3125 (inches)
- 6) GAS COMPOSITION: (percent by volume)  
CO<sub>2</sub> 12.40, O<sub>2</sub> 7.38, CO 0.0  
SO<sub>2</sub> 0.34, N<sub>2</sub> 78.94, Ar 0.94
- 7) NO. OF READINGS: 48  
TIME BETWEEN READINGS: 4.0 min.  
TEST POINTS/TRVERSE: 12  
NO. OF TRAVERSES: 2
- 8) CONDENSED WATER: 388.59 (grams)  
WATER CAUGHT BY DRYING AGENTS: 18.75 (grams)  
MOISTURE CONTENT, B<sub>wo</sub>: 0.160
- 9) MOLECULAR WEIGHT OF GAS:  
30.5 DRY BASIS (lb<sub>m</sub>/lb mole)  
28.5 WET BASIS (lb<sub>m</sub>/lb mole)
- 10) VOLUME OF GAS SAMPLED: 111.2 (acf)
- 11) AVERAGE STACK VELOCITY: 55.95 (ft/s) AVG. TEMP: 925 (°F)  
AVERAGE VOLUMETRIC FLOW RATE: 42194 (acfm)

TABLE 111.27 FIELD DATA SUMMARY SHEET







| Sample<br>Analysis        | Test No 3 |                              | Date June 30, 1983 |        | Nevlis                             |                                           |                                                            |
|---------------------------|-----------|------------------------------|--------------------|--------|------------------------------------|-------------------------------------------|------------------------------------------------------------|
|                           | PCN       | Micrograms<br>LUP.<br>1,2,3. | LUP.<br>4,5        | Filter | Total<br>elemental<br>Weight<br>pg | Elemental<br>Concen-<br>tration<br>pg/ref | Maximum Possible<br>Elemental<br>Emission<br>Rate<br>gm/hr |
| Volume (all)              | 390.      | 1350                         | 385.               |        | $5.5 \times 10^3$ kg/d (total)     |                                           |                                                            |
| Total Particulate<br>(mg) | 59.77     | 54147.                       | —                  | 28.38  | $5.5 \times 10^3$ kg/d (front end) |                                           |                                                            |
| Cr Chromium               | 31.0      | 27.0                         | 230.               | 20.0   | 310.                               | 3.0                                       | 2.3                                                        |
| Fe Iron                   | 39.0      | 2700                         | 730.               | 20.0   | 3500                               | 34.                                       | 26.                                                        |
| Mn Manganese              | 7.3       | 9.5                          | 12.0               | 5.0    | 34.0                               | 0.33                                      | 0.25                                                       |
| Ni Nickel                 | 11.0      | 27.0                         | 77.0               | 20.0   | 160.                               | 1.6                                       | 1.2                                                        |
| Zn Zinc                   | 43.0      | 110.                         | 96.0               | 1.0    | 250.                               | 2.4                                       | 1.8                                                        |

All elements except those in boxes ☐ are below the limit of detection.

Table 111.30: Summary of Incinerator Stack Source Sampling Data for Elements Whose Presence was Detected at the Gulf-Nevlis Plant, Test #3

- 1) CLIENT NAME: ENERGY RESOURCES CONSERVATION BOARD  
LOCATION: Gold Creek  
COMPANY: Petro Canada
- 2) TEST NO: Prelim      DATE: July 2, 1983
- 3) PRODUCTION: Not Recorded
- 4) BAROMETRIC PRESSURE: 27.36      (inches Hg)  
STATIC PRESSURE: -0.8      (inches H<sub>2</sub>O)  
STACK DIMENSIONS: DIAMETER (D) 3-7/16(feet)
- 5) PITOT TUBE COEFFICIENT: 0.795  
METER CORRECTION FACTOR: 1.0  
NOZZLE DIAMETER: 0.375      (inches)
- 6) GAS COMPOSITION: (percent by volume)  
CO<sub>2</sub> 6.99,      O<sub>2</sub> 10.0,      CO 0.0  
SO<sub>2</sub> 0.17,      N<sub>2</sub> 81.86,      Ar 0.98
- 7) NO. OF READINGS: 48  
TIME BETWEEN READINGS: 5.0      min.  
TEST POINTS/TRVERSE: 6  
NO. OF TRAVERSES: 2
- 8) CONDENSED WATER: 329.22      (grams)  
WATER CAUGHT BY DRYING AGENTS: 14.65 (grams)  
MOISTURE CONTENT, B<sub>wo</sub>: 0.147
- 9) MOLECULAR WEIGHT OF GAS:  
                         29.7      DRY BASIS (lb<sub>m</sub>/lb mole)  
                         28.0      WET BASIS (lb<sub>m</sub>/lb mole)
- 10) VOLUME OF GAS SAMPLED: 104.97      (acf)
- 11) AVERAGE STACK VELOCITY: 28.90      (ft/s)AVG.TEMP: 949 (°F)  
AVERAGE VOLUMETRIC FLOW RATE: 16126      (acfm)

TABLE 111.31 FIELD DATA SUMMARY SHEET

STACK NO. 1 TEST NO. 8 TRAVERSE NO. 1

| SAMPLE POINT (NO.) | TIME (MIN) | STACK TEMP DEG. F | DELTA P (IN H2O) | VEL (FT/S) | DELTA H (IN H2O) | GAS VOLUME (CU FT) | Y E M P E R A T U R E (DEG. F) | GAS INLET | GAS OUT | PUMP VAC (IN HG) | ISO KINETIC VARIATION (PERCENT) |
|--------------------|------------|-------------------|------------------|------------|------------------|--------------------|--------------------------------|-----------|---------|------------------|---------------------------------|
| 0                  | 0          | 945               | 0.050            | 20.57      | 0.52             | 655.08             | 405                            | 50        | 75      | 1.00             | 0.00                            |
| 1                  | 5          | 943               | 0.050            | 20.57      | 0.52             | 855.62             | 407                            | 50        | 75      | 1.00             | 100.45                          |
| 1                  | 10         | 943               | 0.050            | 20.57      | 0.52             | 857.37             | 409                            | 45        | 75      | 1.00             | 94.71                           |
| 1                  | 15         | 945               | 0.083            | 26.32      | 0.83             | 858.95             | 410                            | 45        | 78      | 1.00             | 96.17                           |
| 2                  | 20         | 945               | 0.083            | 26.32      | 0.83             | 863.75             | 410                            | 45        | 78      | 1.00             | 92.16                           |
| 2                  | 25         | 945               | 0.100            | 29.09      | 1.04             | 863.09             | 410                            | 44        | 85      | 4.00             | 106.91                          |
| 2                  | 30         | 947               | 0.100            | 29.12      | 1.04             | 865.13             | 411                            | 44        | 85      | 4.00             | 107.56                          |
| 2                  | 35         | 947               | 0.100            | 29.12      | 1.04             | 867.25             | 411                            | 45        | 87      | 4.00             | 107.80                          |
| 2                  | 40         | 947               | 0.100            | 29.12      | 1.04             | 869.62             | 410                            | 45        | 85      | 5.00             | 105.75                          |
| 3                  | 45         | 948               | 0.120            | 31.91      | 1.25             | 871.93             | 410                            | 45        | 83      | 5.00             | 102.08                          |
| 3                  | 50         | 950               | 0.120            | 31.91      | 1.25             | 874.39             | 410                            | 45        | 85      | 5.00             | 102.65                          |
| 3                  | 55         | 950               | 0.120            | 31.93      | 1.25             | 876.86             | 410                            | 45        | 87      | 5.00             | 107.43                          |
| 4                  | 60         | 950               | 0.120            | 31.93      | 1.25             | 879.21             | 410                            | 45        | 87      | 5.00             | 107.43                          |
| 4                  | 65         | 950               | 0.120            | 31.93      | 1.25             | 881.80             | 410                            | 45        | 87      | 5.00             | 107.43                          |
| 4                  | 70         | 950               | 0.120            | 31.93      | 1.25             | 884.15             | 410                            | 45        | 87      | 5.00             | 107.43                          |
| 4                  | 75         | 950               | 0.120            | 31.93      | 1.25             | 886.72             | 410                            | 45        | 87      | 5.00             | 107.43                          |
| 4                  | 80         | 950               | 0.120            | 31.93      | 1.25             | 889.22             | 410                            | 45        | 87      | 5.00             | 107.43                          |
| 4                  | 85         | 950               | 0.120            | 31.93      | 1.25             | 891.79             | 410                            | 45        | 87      | 5.00             | 107.43                          |
| 5                  | 90         | 950               | 0.120            | 31.93      | 1.25             | 894.29             | 410                            | 45        | 87      | 5.00             | 107.43                          |
| 5                  | 95         | 950               | 0.120            | 31.93      | 1.25             | 896.92             | 410                            | 45        | 87      | 5.00             | 107.43                          |
| 5                  | 100        | 950               | 0.120            | 31.93      | 1.25             | 899.37             | 410                            | 45        | 87      | 5.00             | 107.43                          |
| 6                  | 105        | 950               | 0.120            | 31.93      | 1.25             | 901.77             | 410                            | 45        | 87      | 5.00             | 107.43                          |
| 6                  | 110        | 950               | 0.120            | 31.93      | 1.25             | 904.16             | 410                            | 45        | 87      | 5.00             | 107.43                          |
| 6                  | 115        | 950               | 0.120            | 31.93      | 1.25             | 906.40             | 410                            | 45        | 87      | 5.00             | 107.43                          |
| 6                  | 120        | 950               | 0.120            | 31.93      | 1.25             | 908.40             | 410                            | 45        | 87      | 5.00             | 107.43                          |

Table 111.32: Field Sampling Data for Preliminary Test  
Petro Canada-Gold Creek, July 2, 1983  
Traverse #1

STACK NO. 1 TEST NO. 2 TRAVERSE NO. 2

| SAMPLE<br>POINT<br>(NO) | TIME<br>(MIN) | STACK<br>TEMP<br>DEG.F | DELTA P<br>(IN H <sub>2</sub> O) | VEL<br>(FT/S) | DELTA H<br>(IN H <sub>2</sub> O) | GAS METER<br>VOLUME<br>(CU FT) | PHOS | TEMP<br>JVEN | R A<br>OUTLET | Y J R E<br>IMPIRGERS<br>INLET | GAS<br>METER<br>JUF | S (DEG.F) | PUMP<br>VAC<br>(IN HG) | ISOMETRIC<br>VARIATION<br>(PERCENT) |
|-------------------------|---------------|------------------------|----------------------------------|---------------|----------------------------------|--------------------------------|------|--------------|---------------|-------------------------------|---------------------|-----------|------------------------|-------------------------------------|
| 0                       | 0             | 950                    | 0.030                            | 20.01         | 0.51                             | 908.52                         | 410  | 220          |               | 55                            | 70                  | 70        | 2.20                   | 0.00                                |
| 1                       | 5             | 945                    | 0.050                            | 20.65         | 0.51                             | 910.08                         | 412  | 240          |               | 45                            | 70                  | 70        | 2.20                   | 103.73                              |
| 1                       | 10            | 945                    | 0.050                            | 20.37         | 0.51                             | 911.42                         | 412  | 350          |               | 45                            | 70                  | 70        | 2.00                   | 102.73                              |
| 1                       | 15            | 945                    | 0.050                            | 20.57         | 0.51                             | 912.26                         | 415  | 350          |               | 45                            | 71                  | 70        | 2.00                   | 107.94                              |
| 2                       | 20            | 950                    | 0.100                            | 20.15         | 1.00                             | 917.55                         | 420  | 370          |               | 45                            | 72                  | 70        | 4.00                   | 100.46                              |
| 2                       | 25            | 953                    | 0.100                            | 20.13         | 1.00                             | 917.55                         | 420  | 370          |               | 40                            | 75                  | 70        | 4.00                   | 106.10                              |
| 2                       | 30            | 953                    | 0.100                            | 20.13         | 1.00                             | 919.59                         | 415  | 245          |               | 45                            | 75                  | 70        | 4.00                   | 104.45                              |
| 2                       | 35            | 953                    | 0.100                            | 20.09         | 1.00                             | 921.70                         | 415  | 255          |               | 45                            | 75                  | 70        | 4.00                   | 107.74                              |
| 2                       | 40            | 953                    | 0.120                            | 21.93         | 1.25                             | 923.22                         | 415  | 260          |               | 45                            | 76                  | 71        | 5.00                   | 94.37                               |
| 2                       | 45            | 950                    | 0.120                            | 21.93         | 1.25                             | 926.14                         | 420  | 260          |               | 45                            | 76                  | 72        | 5.50                   | 102.52                              |
| 2                       | 50            | 955                    | 0.120                            | 21.99         | 1.25                             | 931.18                         | 420  | 260          |               | 45                            | 76                  | 73        | 5.50                   | 101.75                              |
| 2                       | 55            | 955                    | 0.120                            | 21.93         | 1.25                             | 933.72                         | 425  | 265          |               | 45                            | 80                  | 74        | 5.50                   | 103.76                              |
| 4                       | 60            | 950                    | 0.120                            | 21.87         | 1.25                             | 936.25                         | 420  | 265          |               | 50                            | 80                  | 74        | 5.50                   | 106.77                              |
| 4                       | 65            | 950                    | 0.120                            | 21.93         | 1.25                             | 938.53                         | 420  | 265          |               | 50                            | 81                  | 75        | 5.50                   | 93.65                               |
| 4                       | 70            | 950                    | 0.120                            | 21.87         | 1.25                             | 940.74                         | 420  | 265          |               | 50                            | 81                  | 75        | 5.50                   | 92.95                               |
| 4                       | 75            | 950                    | 0.120                            | 21.93         | 1.25                             | 943.34                         | 415  | 265          |               | 50                            | 81                  | 75        | 5.50                   | 96.81                               |
| 5                       | 80            | 950                    | 0.120                            | 21.93         | 1.25                             | 945.34                         | 420  | 265          |               | 50                            | 81                  | 75        | 5.50                   | 96.32                               |
| 5                       | 85            | 950                    | 0.120                            | 21.93         | 1.25                             | 947.89                         | 415  | 265          |               | 55                            | 83                  | 79        | 5.50                   | 106.59                              |
| 5                       | 90            | 950                    | 0.120                            | 21.93         | 1.25                             | 950.10                         | 415  | 265          |               | 55                            | 84                  | 79        | 5.50                   | 92.63                               |
| 5                       | 95            | 950                    | 0.070                            | 24.39         | 0.68                             | 951.80                         | 410  | 270          |               | 55                            | 84                  | 79        | 3.00                   | 92.47                               |
| 6                       | 100           | 955                    | 0.070                            | 24.43         | 0.68                             | 953.72                         | 410  | 270          |               | 55                            | 84                  | 79        | 3.00                   | 103.08                              |
| 6                       | 105           | 950                    | 0.070                            | 24.39         | 0.68                             | 955.59                         | 410  | 245          |               | 55                            | 85                  | 80        | 3.00                   | 102.28                              |
| 6                       | 110           | 950                    | 0.070                            | 24.39         | 0.68                             | 957.42                         | 410  | 240          |               | 60                            | 85                  | 80        | 3.00                   | 103.92                              |
| 6                       | 115           | 950                    | 0.070                            | 24.39         | 0.68                             | 959.17                         | 410  | 240          |               | 60                            | 85                  | 80        | 3.00                   | 103.92                              |
| 6                       | 120           | 950                    | 0.070                            | 24.39         | 0.68                             | 959.17                         | 410  | 240          |               | 60                            | 85                  | 80        | 3.00                   | 103.92                              |

Table 111.33: Field Sampling Data for Preliminary Test  
Petro Canada-Gold Creek, July 2, 1983  
Traverse #2



- 1) CLIENT NAME: ENERGY RESOURCES CONSERVATION BOARD  
LOCATION: Gold Creek  
COMPANY: Petro Canada
- 2) TEST NO: 1 DATE: July 3, 1983
- 3) PRODUCTION: Not Recorded
- 4) BAROMETRIC PRESSURE: 27.54 (inches Hg)  
STATIC PRESSURE: -0.8 (inches H<sub>2</sub>O)  
STACK DIMENSIONS: DIAMETER (D) 3-7/16(feet)
- 5) PITOT TUBE COEFFICIENT: 0.795  
METER CORRECTION FACTOR: 1.0  
NOZZLE DIAMETER: 0.375 (inches)
- 6) GAS COMPOSITION: (percent by volume)  
CO<sub>2</sub> 6.46, O<sub>2</sub> 10.81, CO 0.0  
SO<sub>2</sub> 0.21, N<sub>2</sub> 81.55, Ar 0.97
- 7) NO. OF READINGS: 48  
TIME BETWEEN READINGS: 5.0 min.  
TEST POINTS/TRVERSE: 6  
NO. OF TRAVERSES: 2
- 8) CONDENSED WATER: 317.091 (grams)  
WATER CAUGHT BY DRYING AGENTS: 18.94 (grams)  
MOISTURE CONTENT, B<sub>WO</sub>: 0.144
- 9) MOLECULAR WEIGHT OF GAS:  
29.7 DRY BASIS (lb<sub>m</sub>/lb mole)  
28.0 WET BASIS (lb<sub>m</sub>/lb mole)
- 10) VOLUME OF GAS SAMPLED: 106.39 (acf)
- 11) AVERAGE STACK VELOCITY: 28.58 (ft/s) AVG. TEMP: 951 (°F)  
AVERAGE VOLUMETRIC FLOW RATE: 15948 (acfm)

TABLE 111.34 FIELD DATA SUMMARY SHEET



STACK NO. 1 TEST NO. 1 TRAVERSE NO. 1

| SAMPLE<br>POINT<br>(NO.) | TIME<br>(MIN) | STACK<br>TEMP<br>DEG.F | DELTA P<br>(IN H2O) | VEL<br>(FT/S) | DELTA H<br>(IN H2O) | GAS METER<br>VOLUME<br>(CUFT) | PROBE | TEMP<br>OVEN | OUTLET | AIR<br>IMPINGERS<br>INLET | TEMP<br>GAS<br>METER | ISOKINETIC<br>VARIATION<br>(PERCENT) |
|--------------------------|---------------|------------------------|---------------------|---------------|---------------------|-------------------------------|-------|--------------|--------|---------------------------|----------------------|--------------------------------------|
| 0                        | 0             | 953                    | 0.040               | 26.01         | 0.81                | 17.04                         | 410   | 250          | 55     | 65                        | 70                   | 0.00                                 |
| 1                        | 5             | 953                    | 0.040               | 26.01         | 0.81                | 21.33                         | 410   | 250          | 55     | 65                        | 70                   | 104.71                               |
| 1                        | 10            | 955                    | 0.040               | 26.01         | 0.81                | 23.43                         | 410   | 250          | 55     | 65                        | 71                   | 98.58                                |
| 1                        | 15            | 955                    | 0.040               | 26.01         | 0.81                | 25.43                         | 410   | 250          | 55     | 65                        | 71                   | 98.73                                |
| 2                        | 20            | 955                    | 0.040               | 26.01         | 0.81                | 27.46                         | 410   | 250          | 49     | 125                       | 73                   | 100.07                               |
| 2                        | 25            | 952                    | 0.040               | 27.50         | 0.92                | 29.51                         | 410   | 250          | 49     | 160                       | 73                   | 100.07                               |
| 2                        | 30            | 952                    | 0.040               | 27.50         | 0.92                | 31.53                         | 410   | 250          | 49     | 163                       | 77                   | 98.10                                |
| 2                        | 35            | 954                    | 0.040               | 27.50         | 0.92                | 33.63                         | 410   | 250          | 49     | 163                       | 81                   | 101.19                               |
| 2                        | 40            | 954                    | 0.040               | 27.50         | 0.92                | 35.72                         | 410   | 250          | 49     | 163                       | 81                   | 101.19                               |
| 3                        | 45            | 953                    | 0.040               | 27.50         | 0.92                | 37.81                         | 410   | 250          | 50     | 170                       | 82                   | 101.52                               |
| 3                        | 50            | 950                    | 0.040               | 27.50         | 0.92                | 39.92                         | 410   | 250          | 51     | 172                       | 83                   | 101.52                               |
| 3                        | 55            | 952                    | 0.040               | 26.00         | 0.92                | 41.95                         | 410   | 250          | 51     | 171                       | 83                   | 103.66                               |
| 3                        | 60            | 952                    | 0.040               | 27.50         | 0.92                | 44.11                         | 410   | 250          | 51     | 173                       | 84                   | 103.66                               |
| 4                        | 65            | 952                    | 0.040               | 27.50         | 0.92                | 46.25                         | 410   | 250          | 53     | 174                       | 85                   | 103.19                               |
| 4                        | 70            | 950                    | 0.040               | 27.50         | 0.92                | 48.42                         | 410   | 250          | 55     | 175                       | 85                   | 103.19                               |
| 4                        | 75            | 950                    | 0.040               | 27.50         | 0.92                | 50.60                         | 410   | 250          | 55     | 176                       | 86                   | 104.66                               |
| 4                        | 80            | 950                    | 0.040               | 27.50         | 0.92                | 52.78                         | 410   | 250          | 56     | 177                       | 86                   | 104.66                               |
| 5                        | 85            | 952                    | 0.040               | 27.50         | 0.92                | 54.95                         | 410   | 250          | 56     | 172                       | 86                   | 104.35                               |
| 5                        | 90            | 952                    | 0.040               | 27.50         | 0.92                | 57.13                         | 410   | 250          | 60     | 172                       | 88                   | 104.35                               |
| 5                        | 95            | 952                    | 0.040               | 27.50         | 0.92                | 59.31                         | 410   | 250          | 60     | 172                       | 89                   | 104.35                               |
| 6                        | 100           | 952                    | 0.040               | 27.50         | 0.92                | 61.50                         | 410   | 250          | 61     | 171                       | 89                   | 104.35                               |
| 6                        | 105           | 952                    | 0.040               | 26.00         | 0.81                | 63.67                         | 410   | 250          | 63     | 172                       | 89                   | 104.35                               |
| 6                        | 110           | 950                    | 0.040               | 25.50         | 0.81                | 65.84                         | 410   | 250          | 63     | 172                       | 89                   | 99.37                                |
| 6                        | 115           | 950                    | 0.040               | 25.50         | 0.81                | 67.92                         | 410   | 250          | 63     | 172                       | 89                   | 99.37                                |
| 6                        | 120           | 950                    | 0.040               | 25.50         | 0.81                | 69.99                         | 410   | 250          | 66     | 173                       | 90                   | 96.55                                |
| 6                        |               |                        |                     |               |                     | 72.06                         | 410   | 250          |        |                           |                      | 107.31                               |

Table 111.35: Field Sampling Data for Test #1  
Petro Canada-Gold Creek, July 3, 1983  
Traverse #1

| STACK NO. 1       |            | TEST NO. 1       |                  | TRAVERSE NO. 2 |                  | T E M P E R A T U R E S (DEG.F) |       | PUMP VAC (IN HG)                |              | ISOKINETIC VARIATION (PERCENT) |     |
|-------------------|------------|------------------|------------------|----------------|------------------|---------------------------------|-------|---------------------------------|--------------|--------------------------------|-----|
| SAMPLE POINT (IN) | TIME (MIN) | STACK TEMP DEG.F | DELTA P (IN H2O) | VEL (FT/S)     | DELTA H (IN H2O) | GAS METER VOLUME (CUFT)         | PROBE | Y E M P E R A T U R E S (DEG.F) | OUTLET INLET | IN                             | OUT |
| 0                 | 0          | 950              | 0.380            | 25.38          | 0.81             | 75.04                           | 410   | 85                              | 75           | 80                             | 72  |
| 1                 | 5          | 950              | 0.380            | 25.38          | 0.81             | 75.86                           | 400   | 85                              | 53           | 80                             | 72  |
| 1                 | 10         | 950              | 0.380            | 25.38          | 0.81             | 80.92                           | 410   | 85                              | 54           | 80                             | 72  |
| 1                 | 15         | 950              | 0.380            | 25.38          | 0.81             | 82.91                           | 410   | 85                              | 54           | 80                             | 72  |
| 1                 | 20         | 950              | 0.380            | 25.38          | 0.81             | 85.16                           | 410   | 85                              | 54           | 80                             | 72  |
| 1                 | 25         | 950              | 0.380            | 25.38          | 0.81             | 87.42                           | 410   | 85                              | 54           | 80                             | 72  |
| 2                 | 30         | 950              | 0.380            | 25.38          | 0.81             | 89.65                           | 410   | 85                              | 54           | 80                             | 72  |
| 2                 | 35         | 950              | 0.380            | 25.38          | 0.81             | 91.88                           | 410   | 85                              | 54           | 80                             | 72  |
| 2                 | 40         | 950              | 0.380            | 25.38          | 0.81             | 94.13                           | 410   | 85                              | 54           | 80                             | 72  |
| 2                 | 45         | 950              | 0.380            | 25.38          | 0.81             | 96.33                           | 410   | 85                              | 54           | 80                             | 72  |
| 3                 | 50         | 950              | 0.380            | 25.38          | 0.81             | 98.53                           | 410   | 85                              | 54           | 80                             | 72  |
| 3                 | 55         | 950              | 0.380            | 25.38          | 0.81             | 100.79                          | 410   | 85                              | 54           | 80                             | 72  |
| 3                 | 60         | 950              | 0.380            | 25.38          | 0.81             | 103.01                          | 410   | 85                              | 54           | 80                             | 72  |
| 3                 | 65         | 950              | 0.380            | 25.38          | 0.81             | 105.21                          | 410   | 85                              | 54           | 80                             | 72  |
| 4                 | 70         | 950              | 0.380            | 25.38          | 0.81             | 107.41                          | 410   | 85                              | 54           | 80                             | 72  |
| 4                 | 75         | 950              | 0.380            | 25.38          | 0.81             | 109.61                          | 410   | 85                              | 54           | 80                             | 72  |
| 4                 | 80         | 950              | 0.380            | 25.38          | 0.81             | 111.81                          | 410   | 85                              | 54           | 80                             | 72  |
| 4                 | 85         | 950              | 0.380            | 25.38          | 0.81             | 114.01                          | 410   | 85                              | 54           | 80                             | 72  |
| 4                 | 90         | 950              | 0.380            | 25.38          | 0.81             | 116.21                          | 410   | 85                              | 54           | 80                             | 72  |
| 5                 | 95         | 950              | 0.380            | 25.38          | 0.81             | 118.41                          | 410   | 85                              | 54           | 80                             | 72  |
| 5                 | 100        | 950              | 0.380            | 25.38          | 0.81             | 120.61                          | 410   | 85                              | 54           | 80                             | 72  |
| 5                 | 105        | 950              | 0.380            | 25.38          | 0.81             | 122.81                          | 410   | 85                              | 54           | 80                             | 72  |
| 5                 | 110        | 950              | 0.380            | 25.38          | 0.81             | 125.01                          | 410   | 85                              | 54           | 80                             | 72  |
| 6                 | 115        | 950              | 0.380            | 25.38          | 0.81             | 127.21                          | 410   | 85                              | 54           | 80                             | 72  |
| 6                 | 120        | 950              | 0.380            | 25.38          | 0.81             | 129.41                          | 410   | 85                              | 54           | 80                             | 72  |

Table 111.36: Field Sampling Data for Test #1  
Petro Canada-Gold Creek, July 3, 1983  
Traverse #2

| Sample Analysis        | Test no 1         | Date   | Gold Creek Maximum Possible |                                                  |                                               |      |
|------------------------|-------------------|--------|-----------------------------|--------------------------------------------------|-----------------------------------------------|------|
|                        |                   |        | total elemental weight pg   | Elemental Concentration $\mu\text{g}/\text{ref}$ | Elemental Emission Rate $\text{gm}/\text{hr}$ |      |
| Sample From            | <u>Micrograms</u> |        |                             | Filter                                           |                                               |      |
|                        | 1st               | 2nd    | 3rd                         |                                                  |                                               |      |
| Volume (ml)            | 450.              | 1065.  | 405.                        | 26.68                                            | $2.4 \times 10^3 \text{ kg/g (total)}$        |      |
|                        | 47.40             | 33098. | —                           |                                                  | $5.4 \text{ kg/g (front end)}$                |      |
| Total Particulate (mg) | 1.4               | 4.3    | 1.2                         | 0.5                                              | 7.3                                           | 0.02 |
|                        | 2.7               | 17.0   | 2.0                         | 1.0                                              | 23.0                                          | 0.07 |
| Fe Iron                | 41.0              | 120.   | 20.0                        | 30.0                                             | 210.                                          | 0.63 |
|                        | 4.1               | 12.0   | 3.2                         | 1.0                                              | 42.0                                          | 0.13 |
| Zn Zinc                |                   |        |                             |                                                  |                                               |      |

All elements except those in boxes ☐ are below the limit of detection

All elements except those in boxes ☐ are below the limit of detection

Table 111.37: Summary of Incinerator Stack Source Sampling Data for Elements Whose Presence was Detected at the Petro Canada-Gold Creek Plant, Test #1

- 1) CLIENT NAME: ENERGY RESOURCES CONSERVATION BOARD  
LOCATION: Gold Creek  
COMPANY: Petro Canada
- 2) TEST NO: 2 DATE: July 4, 1983
- 3) PRODUCTION: Not Recorded
- 4) BAROMETRIC PRESSURE: 27.69 (inches Hg)  
STATIC PRESSURE: -0.8 (inches H<sub>2</sub>O)  
STACK DIMENSIONS: DIAMETER (D) 3-7/16(feet)
- 5) PITOT TUBE COEFFICIENT: 0.795  
METER CORRECTION FACTOR: 1.0  
NOZZLE DIAMETER: 0.375 (inches)
- 6) GAS COMPOSITION: (percent by volume)  
CO<sub>2</sub> 6.98, O<sub>2</sub> 9.99, CO 0.0  
SO<sub>2</sub> 0.30, N<sub>2</sub> 81.75, Ar 0.98
- 7) NO. OF READINGS: 48  
TIME BETWEEN READINGS: 5.0 min.  
TEST POINTS/TRVERSE: 6  
NO. OF TRAVERSES: 2
- 8) CONDENSED WATER: 378.19 (grams)  
WATER CAUGHT BY DRYING AGENTS: 9.71 (grams)  
MOISTURE CONTENT, B<sub>wo</sub>: 0.165
- 9) MOLECULAR WEIGHT OF GAS:  
29.8 DRY BASIS (lb<sub>m</sub>/lb mole)  
27.8 WET BASIS (lb<sub>m</sub>/lb mole)
- 10) VOLUME OF GAS SAMPLED: 102.82 (acf)
- 11) AVERAGE STACK VELOCITY: 28.97 (ft/s) AVG. TEMP: 951 (°F)  
AVERAGE VOLUMETRIC FLOW RATE: 16163 (acfm)

TABLE 111.38 FIELD DATA SUMMARY SHEET



STACK NO. 1 TEST NO. 2 TRAVERSE NO. 2

| SAMPLE<br>POINT<br>(NO.) | TIME<br>(MIN) | STACK<br>TEMP<br>DEG.F | DELTA P<br>(IN H2O) | VEL<br>(FT/S) | DELTA H<br>(IN H2O) | GAS METER<br>(CUFT) | PROBE | I E M P E N | T U N E | A | OUTLET | INLET | GAS<br>METER | S (DEG.F) | PUMP<br>VAC<br>(IN HG) | ISKINETIC<br>VARIATION<br>(PERCENT) |
|--------------------------|---------------|------------------------|---------------------|---------------|---------------------|---------------------|-------|-------------|---------|---|--------|-------|--------------|-----------|------------------------|-------------------------------------|
| 0                        | 0             | 955                    | 0.080               | 26.02         | 0.81                | 221.28              | 425   | 200         | 63      |   |        | 68    | 78           | 78        | 5.50                   | 0.00                                |
| 1                        | 5             | 955                    | 0.080               | 26.02         | 0.81                | 223.07              | 425   | 210         | 60      |   |        | 65    | 78           | 78        | 5.50                   | 94.36                               |
| 1                        | 10            | 955                    | 0.080               | 26.02         | 0.81                | 224.48              | 430   | 230         | 50      |   |        | 115   | 79           | 79        | 5.50                   | 95.31                               |
| 1                        | 15            | 955                    | 0.080               | 26.02         | 0.81                | 226.93              | 425   | 230         | 50      |   |        | 115   | 81           | 81        | 5.50                   | 107.32                              |
| 2                        | 20            | 955                    | 0.080               | 26.02         | 0.81                | 228.97              | 425   | 250         | 51      |   |        | 127   | 81           | 81        | 5.50                   | 107.34                              |
| 2                        | 25            | 955                    | 0.080               | 26.02         | 0.81                | 230.99              | 425   | 250         | 51      |   |        | 127   | 82           | 82        | 5.50                   | 105.77                              |
| 2                        | 30            | 955                    | 0.080               | 26.02         | 0.81                | 232.90              | 430   | 265         | 51      |   |        | 133   | 82           | 82        | 5.50                   | 93.45                               |
| 2                        | 35            | 955                    | 0.080               | 26.02         | 0.81                | 234.74              | 430   | 265         | 51      |   |        | 133   | 83           | 83        | 5.50                   | 93.45                               |
| 2                        | 40            | 955                    | 0.080               | 26.02         | 0.81                | 236.53              | 430   | 270         | 52      |   |        | 133   | 83           | 83        | 5.50                   | 93.45                               |
| 2                        | 45            | 955                    | 0.080               | 26.02         | 0.81                | 238.37              | 425   | 270         | 52      |   |        | 145   | 84           | 84        | 5.50                   | 96.26                               |
| 3                        | 50            | 955                    | 0.120               | 31.87         | 1.23                | 240.89              | 425   | 280         | 52      |   |        | 145   | 84           | 84        | 10.00                  | 107.18                              |
| 3                        | 55            | 955                    | 0.120               | 31.87         | 1.23                | 243.17              | 425   | 270         | 52      |   |        | 145   | 85           | 85        | 10.00                  | 96.68                               |
| 3                        | 60            | 955                    | 0.120               | 31.87         | 1.23                | 245.42              | 425   | 268         | 52      |   |        | 145   | 85           | 85        | 10.00                  | 95.49                               |
| 4                        | 65            | 955                    | 0.120               | 31.87         | 1.23                | 247.85              | 425   | 268         | 52      |   |        | 145   | 86           | 86        | 10.00                  | 102.04                              |
| 4                        | 70            | 955                    | 0.120               | 31.87         | 1.23                | 250.06              | 425   | 269         | 55      |   |        | 147   | 88           | 88        | 10.00                  | 93.55                               |
| 4                        | 75            | 955                    | 0.120               | 31.87         | 1.23                | 252.43              | 425   | 269         | 55      |   |        | 147   | 88           | 88        | 10.00                  | 93.55                               |
| 4                        | 80            | 955                    | 0.120               | 31.87         | 1.23                | 254.63              | 425   | 271         | 55      |   |        | 147   | 89           | 89        | 10.00                  | 92.35                               |
| 5                        | 85            | 955                    | 0.120               | 31.87         | 1.23                | 257.17              | 450   | 271         | 55      |   |        | 140   | 89           | 89        | 10.00                  | 106.82                              |
| 5                        | 90            | 955                    | 0.120               | 31.87         | 1.23                | 259.38              | 450   | 255         | 55      |   |        | 145   | 89           | 89        | 10.00                  | 93.31                               |
| 5                        | 95            | 955                    | 0.120               | 31.87         | 1.23                | 261.99              | 450   | 265         | 55      |   |        | 145   | 89           | 89        | 10.00                  | 106.12                              |
| 5                        | 100           | 955                    | 0.120               | 31.87         | 1.23                | 264.16              | 450   | 265         | 55      |   |        | 145   | 89           | 89        | 10.00                  | 95.99                               |
| 6                        | 105           | 955                    | 0.120               | 31.87         | 1.23                | 266.43              | 450   | 265         | 55      |   |        | 145   | 89           | 89        | 10.00                  | 94.46                               |
| 6                        | 110           | 955                    | 0.120               | 31.87         | 1.23                | 269.91              | 450   | 265         | 55      |   |        | 145   | 89           | 89        | 10.00                  | 106.00                              |
| 6                        | 115           | 955                    | 0.120               | 31.87         | 1.23                | 271.18              | 450   | 265         | 55      |   |        | 145   | 89           | 89        | 10.00                  | 94.52                               |
| 6                        | 120           | 955                    | 0.120               | 31.87         | 1.23                | 273.49              | 450   | 265         | 55      |   |        | 145   | 89           | 89        | 10.00                  | 98.25                               |

Table 111.40: Field Sampling Data for Test #2  
Petro Canada-Gold Creek, July 4, 1983  
Traverse #2

| Sample Analyses        | Test No | 2 | Date | July 4, 1983 | Gold Creek             |                                               |
|------------------------|---------|---|------|--------------|------------------------|-----------------------------------------------|
|                        |         |   |      |              | Total elemental weight | Maximum Possible Elemental Concentration Rate |
|                        |         |   |      |              | pg                     | pg/ref                                        |
|                        |         |   |      |              | Filter                 | Rate                                          |
|                        |         |   |      |              | IMP.                   | Rate                                          |
|                        |         |   |      |              | 1.2, 3.                | 4.5                                           |
|                        |         |   |      |              | 1005                   | 295.                                          |
| Volume (ml)            |         |   |      |              | 19316.                 | 18.18                                         |
| Total Particulate (mg) |         |   |      |              | 29.30                  | 1.4x10 <sup>3</sup> kg/a (total)              |
|                        |         |   |      |              |                        | kg/a (front end)                              |
| Fe Iron                |         |   |      |              | 13.0                   | 1.2                                           |
|                        |         |   |      |              | 60.0                   | 110                                           |
|                        |         |   |      |              | 24.0                   | 10.0                                          |
| Zn Zinc                |         |   |      |              | 4.0                    | 3.0                                           |
|                        |         |   |      |              | 33.0                   | 61.0                                          |
|                        |         |   |      |              | 21.0                   | 0.65                                          |
|                        |         |   |      |              |                        | 0.19                                          |

All elements except those in boxes are below limit of detection

Table 111.41: Summary of Incinerator Stack Source Sampling Data for Elements Whose Presence was Detected at the Petro Canada-Gold Creek Plant, Test #2



- 1) CLIENT NAME: ENERGY RESOURCES CONSERVATION BOARD  
LOCATION: Gold Creek  
COMPANY: Petro Canada
- 2) TEST NO: 3 DATE: July 5, 1983
- 3) PRODUCTION: Not Recorded
- 4) BAROMETRIC PRESSURE: 27.61 (inches Hg)  
STATIC PRESSURE: -0.8 (inches H<sub>2</sub>O)  
STACK DIMENSIONS: DIAMETER (D) 3-7/16(feet)
- 5) PITOT TUBE COEFFICIENT: 0.795  
METER CORRECTION FACTOR: 1.0  
NOZZLE DIAMETER: 0.375 (inches)
- 6) GAS COMPOSITION: (percent by volume)  
CO<sub>2</sub> 6.46, O<sub>2</sub> 10.81, CO 0.0  
SO<sub>2</sub> 0.17, N<sub>2</sub> 81.59, Ar 0.97
- 7) NO. OF READINGS: 48  
TIME BETWEEN READINGS: 5.0 min.  
TEST POINTS/TRVERSE: 6  
NO. OF TRAVERSES: 2
- 8) CONDENSED WATER: 306.27 (grams)  
WATER CAUGHT BY DRYING AGENTS: 6.64 (grams)  
MOISTURE CONTENT, B<sub>wo</sub>: 0.133
- 9) MOLECULAR WEIGHT OF GAS:  
29.6 DRY BASIS (lb<sub>m</sub>/lb mole)  
28.1 WET BASIS (lb<sub>m</sub>/lb mole)
- 10) VOLUME OF GAS SAMPLED: 106.57 (acf)
- 11) AVERAGE STACK VELOCITY: 28.29 (ft/s) AVG. TEMP: 961 (°F)  
AVERAGE VOLUMETRIC FLOW RATE: 15783 (acfm)

TABLE 111.42 FIELD DATA SUMMARY SHEET

STACK NO. 1 TEST (HJ. 3 TRAVERSE NO. 1

| SAMPLE<br>POINT<br>(IN) | TIME<br>(MIN) | STACK<br>TEMP<br>DEG.F | DELTA P<br>(IN H2O) | VEL<br>(FT/S) | DELTA H<br>(IN H2O) | GAS METER<br>VOLUME<br>(CUFT) | PROBE | TEMP<br>(F) | Y U H E S (DEG.F) | GAS<br>METER<br>OUT | PUMP<br>VAC<br>(IN HG) | ISOKINETIC<br>VARIATION<br>(PERCENT) |
|-------------------------|---------------|------------------------|---------------------|---------------|---------------------|-------------------------------|-------|-------------|-------------------|---------------------|------------------------|--------------------------------------|
| 0                       | 0             | 960                    | 0.070               | 24.31         | 0.71                | 322.30                        | 400   | 153         | 50                | 65                  | 5.00                   | 0.10                                 |
| 1                       | 5             | 960                    | 0.070               | 24.31         | 0.71                | 324.41                        | 410   | 155         | 52                | 61                  | 5.00                   | 0.10                                 |
| 1                       | 10            | 960                    | 0.070               | 24.31         | 0.71                | 326.54                        | 410   | 180         | 45                | 69                  | 5.00                   | 0.10                                 |
| 1                       | 15            | 960                    | 0.070               | 24.31         | 0.71                | 327.99                        | 410   | 190         | 45                | 71                  | 5.00                   | 0.10                                 |
| 2                       | 20            | 960                    | 0.070               | 24.31         | 0.71                | 329.72                        | 410   | 192         | 45                | 71                  | 5.00                   | 0.10                                 |
| 2                       | 25            | 960                    | 0.100               | 29.06         | 1.02                | 331.82                        | 410   | 220         | 45                | 73                  | 7.50                   | 0.10                                 |
| 2                       | 30            | 960                    | 0.100               | 29.06         | 1.02                | 333.99                        | 410   | 210         | 45                | 73                  | 7.50                   | 0.10                                 |
| 2                       | 35            | 960                    | 0.100               | 29.06         | 1.02                | 336.28                        | 410   | 210         | 45                | 73                  | 7.50                   | 0.10                                 |
| 2                       | 40            | 960                    | 0.100               | 29.06         | 1.02                | 338.53                        | 410   | 220         | 45                | 73                  | 7.50                   | 0.10                                 |
| 3                       | 45            | 955                    | 0.100               | 29.06         | 1.02                | 340.83                        | 410   | 243         | 50                | 75                  | 7.50                   | 0.10                                 |
| 3                       | 50            | 960                    | 0.100               | 29.06         | 1.02                | 343.13                        | 410   | 260         | 51                | 75                  | 7.50                   | 0.10                                 |
| 3                       | 55            | 960                    | 0.100               | 29.06         | 1.02                | 345.40                        | 410   | 260         | 51                | 75                  | 7.50                   | 0.10                                 |
| 3                       | 60            | 960                    | 0.100               | 29.06         | 1.02                | 347.77                        | 410   | 260         | 51                | 75                  | 7.50                   | 0.10                                 |
| 4                       | 65            | 960                    | 0.100               | 29.06         | 1.02                | 350.13                        | 410   | 260         | 51                | 75                  | 7.50                   | 0.10                                 |
| 4                       | 70            | 960                    | 0.100               | 29.06         | 1.02                | 352.43                        | 410   | 260         | 51                | 75                  | 7.50                   | 0.10                                 |
| 4                       | 75            | 960                    | 0.100               | 29.06         | 1.02                | 354.77                        | 410   | 260         | 51                | 75                  | 7.50                   | 0.10                                 |
| 4                       | 80            | 960                    | 0.100               | 29.06         | 1.02                | 357.12                        | 410   | 260         | 51                | 75                  | 7.50                   | 0.10                                 |
| 5                       | 85            | 960                    | 0.100               | 29.06         | 1.02                | 359.47                        | 410   | 260         | 51                | 75                  | 7.50                   | 0.10                                 |
| 5                       | 90            | 960                    | 0.100               | 29.06         | 1.02                | 361.82                        | 410   | 260         | 51                | 75                  | 7.50                   | 0.10                                 |
| 5                       | 95            | 960                    | 0.100               | 29.06         | 1.02                | 364.17                        | 410   | 260         | 51                | 75                  | 7.50                   | 0.10                                 |
| 6                       | 100           | 960                    | 0.110               | 30.47         | 1.03                | 366.53                        | 410   | 260         | 51                | 75                  | 7.50                   | 0.10                                 |
| 6                       | 105           | 960                    | 0.110               | 30.47         | 1.03                | 368.88                        | 410   | 260         | 51                | 75                  | 7.50                   | 0.10                                 |
| 6                       | 110           | 960                    | 0.110               | 30.47         | 1.03                | 371.23                        | 410   | 260         | 51                | 75                  | 7.50                   | 0.10                                 |
| 6                       | 115           | 960                    | 0.110               | 30.47         | 1.03                | 373.58                        | 410   | 260         | 51                | 75                  | 7.50                   | 0.10                                 |
| 6                       | 120           | 960                    | 0.110               | 30.47         | 1.03                | 375.93                        | 410   | 260         | 51                | 75                  | 7.50                   | 0.10                                 |

Table 111.43: Field Sampling Data for Test #3  
Petro Canada-Gold Creek, July 5, 1983  
Traverse #1

STACK NO. 1 TEST NO. 3 TRAVERSE NO. 2

| SAMPLE<br>POINT<br>(NOT) | TIME<br>(MIN) | STACK<br>TEMP<br>DEG. F | DELTA P<br>(IN H2O) | VEL<br>(FT/S) | DELTA H<br>(IN H2O) | GAS METER<br>VOLUME<br>(CUFT) | PRUNE | TEMPERATURE<br>OVEN | OUTLET<br>IMPIGERS | U N A E<br>INLET | GAS<br>JUL | S (DEG. F)<br>METER | IN | PUMP<br>VAC<br>(IN HG) | ISOKINETIC<br>VARIATION<br>(PERCENT) |
|--------------------------|---------------|-------------------------|---------------------|---------------|---------------------|-------------------------------|-------|---------------------|--------------------|------------------|------------|---------------------|----|------------------------|--------------------------------------|
| 0                        | 0             | 965                     | 0.070               | 24.35         | 0.72                | 407.37                        | 415   | 205                 | 70                 | 99               | 72         | 72                  | 75 | 8.00                   | 0.00                                 |
| 1                        | 5             | 965                     | 0.070               | 24.35         | 0.72                | 409.78                        | 415   | 205                 | 64                 | 103              | 75         | 75                  | 77 | 8.00                   | 104.58                               |
| 1                        | 10            | 965                     | 0.070               | 24.35         | 0.72                | 411.72                        | 415   | 210                 | 55                 | 105              | 78         | 78                  | 80 | 8.00                   | 106.39                               |
| 1                        | 15            | 965                     | 0.070               | 24.35         | 0.72                | 413.54                        | 415   | 210                 | 55                 | 110              | 78         | 78                  | 80 | 8.00                   | 99.08                                |
| 1                        | 20            | 960                     | 0.070               | 24.31         | 0.72                | 415.35                        | 420   | 225                 | 55                 | 112              | 80         | 80                  | 81 | 11.00                  | 92.73                                |
| 2                        | 25            | 960                     | 0.100               | 29.06         | 1.03                | 417.39                        | 420   | 225                 | 55                 | 115              | 80         | 80                  | 81 | 11.00                  | 102.50                               |
| 2                        | 30            | 960                     | 0.100               | 29.06         | 1.03                | 419.37                        | 420   | 230                 | 50                 | 120              | 80         | 80                  | 81 | 11.00                  | 104.04                               |
| 2                        | 35            | 960                     | 0.100               | 29.06         | 1.03                | 422.10                        | 420   | 235                 | 50                 | 125              | 80         | 80                  | 82 | 11.00                  | 105.18                               |
| 2                        | 40            | 960                     | 0.100               | 29.06         | 1.03                | 424.37                        | 420   | 235                 | 52                 | 129              | 80         | 80                  | 82 | 11.00                  | 94.17                                |
| 3                        | 45            | 960                     | 0.100               | 29.06         | 1.03                | 426.55                        | 425   | 240                 | 53                 | 129              | 80         | 80                  | 82 | 11.00                  | 93.00                                |
| 3                        | 50            | 960                     | 0.100               | 29.06         | 1.03                | 428.90                        | 425   | 250                 | 53                 | 130              | 81         | 81                  | 86 | 11.00                  | 106.94                               |
| 3                        | 55            | 960                     | 0.100               | 29.06         | 1.03                | 430.96                        | 425   | 251                 | 53                 | 131              | 82         | 82                  | 89 | 11.00                  | 107.20                               |
| 3                        | 60            | 960                     | 0.100               | 29.06         | 1.03                | 433.33                        | 425   | 251                 | 53                 | 131              | 82         | 82                  | 89 | 11.00                  | 107.19                               |
| 3                        | 65            | 960                     | 0.100               | 29.06         | 1.03                | 435.70                        | 425   | 257                 | 53                 | 133              | 83         | 83                  | 87 | 11.00                  | 107.57                               |
| 4                        | 70            | 960                     | 0.100               | 29.06         | 1.03                | 438.08                        | 425   | 260                 | 53                 | 133              | 85         | 85                  | 89 | 11.00                  | 107.57                               |
| 4                        | 75            | 960                     | 0.100               | 29.06         | 1.03                | 440.47                        | 425   | 260                 | 53                 | 133              | 85         | 85                  | 89 | 11.00                  | 107.61                               |
| 4                        | 80            | 960                     | 0.100               | 29.06         | 1.03                | 442.30                        | 425   | 260                 | 55                 | 130              | 84         | 84                  | 89 | 11.00                  | 107.61                               |
| 5                        | 85            | 965                     | 0.100               | 29.11         | 1.03                | 445.24                        | 425   | 260                 | 55                 | 130              | 84         | 84                  | 89 | 11.00                  | 107.49                               |
| 5                        | 90            | 965                     | 0.100               | 29.11         | 1.03                | 447.63                        | 425   | 260                 | 55                 | 130              | 84         | 84                  | 89 | 11.00                  | 107.49                               |
| 5                        | 95            | 960                     | 0.100               | 29.06         | 1.03                | 450.91                        | 425   | 260                 | 56                 | 130              | 85         | 85                  | 89 | 11.00                  | 107.72                               |
| 5                        | 100           | 965                     | 0.100               | 29.11         | 1.03                | 452.78                        | 425   | 260                 | 57                 | 130              | 85         | 85                  | 89 | 11.00                  | 107.72                               |
| 6                        | 105           | 960                     | 0.100               | 29.06         | 1.03                | 457.16                        | 425   | 260                 | 57                 | 130              | 85         | 85                  | 89 | 11.00                  | 107.41                               |
| 6                        | 110           | 965                     | 0.100               | 29.11         | 1.03                | 459.52                        | 425   | 260                 | 57                 | 130              | 85         | 85                  | 89 | 11.00                  | 107.41                               |
| 6                        | 115           | 965                     | 0.100               | 29.11         | 1.03                | 461.92                        | 425   | 260                 | 58                 | 130              | 85         | 85                  | 90 | 11.00                  | 107.49                               |
| 6                        | 120           | 965                     | 0.100               | 29.11         | 1.03                | 464.32                        | 425   | 260                 | 58                 | 130              | 85         | 85                  | 90 | 11.00                  | 93.05                                |

Table 111.44: Field Sampling Data for Test #3  
Petro Canada-Gold Creek, July 5, 1983  
Traverse #2

| Sample Analysis        | Test No 3         | Date   | July 5, 1983 | Gold Creek                                    |
|------------------------|-------------------|--------|--------------|-----------------------------------------------|
|                        | <u>Micrograms</u> |        |              |                                               |
| Sample From            | PM                | IMP.   | Filter       | Total Elemental Concentration<br>µg           |
|                        |                   | 1.2,3. | 4.5          | µg/ref                                        |
| Volume (ml)            | 460.              | 950.   | 425.         | µg <sup>1.3x10<sup>-3</sup>kg/a (total)</sup> |
| Total Particulate (mg) | 57.16             | 18484. | —            | µg <sup>5.9 kg/a (front end)</sup>            |
| Al Aluminum            | 3800              | 95.0   | 130.         | 42. 12.                                       |
| As Arsenic             | 2.8               | 0.95   | 1.3          | 5.3 0.02                                      |
| Fe Iron                | 41.0              | 86.0   | 170.         | 310 1.2 0.91                                  |
| Zn Zinc                | 41.0              | 90.0   | 3.4          | 140 1.4 0.41                                  |

All elements except those in boxes are below the limit of detection.

All elements except those in boxes ☐ are below the limit of detection.

Table 111.45: Summary of Incinerator Stack Source Sampling Data for Elements Whose Presence was Detected at the Petro Canada-Gold Creek Plant, Test #3

- 1) CLIENT NAME: ENERGY RESOURCES CONSERVATION BOARD  
LOCATION: Rainbow Lake  
COMPANY: Canterra Energy Limited
- 2) TEST NO: Prelim DATE: July 7, 1983
- 3) PRODUCTION: Not Recorded
- 4) BAROMETRIC PRESSURE: 28.4 (inches Hg)  
STATIC PRESSURE: -0.6 (inches H<sub>2</sub>O)  
STACK DIMENSIONS: DIAMETER (D) 5 (feet)
- 5) PITOT TUBE COEFFICIENT: 0.790  
METER CORRECTION FACTOR: 1.0  
NOZZLE DIAMETER: 0.375 (inches)
- 6) GAS COMPOSITION: (percent by volume)  
CO<sub>2</sub> 3.24, O<sub>2</sub> 10.55, CO 0.00  
SO<sub>2</sub> 0.46, N<sub>2</sub> 84.73, Ar 1.02
- 7) NO. OF READINGS: 40  
TIME BETWEEN READINGS: 6.0 min.  
TEST POINTS/TRVERSE: 10  
NO. OF TRAVERSES: 2
- 8) CONDENSED WATER: 600.27 (grams)  
WATER CAUGHT BY DRYING AGENTS: 14.48 (grams)  
MOISTURE CONTENT, B<sub>wo</sub>: 0.186
- 9) MOLECULAR WEIGHT OF GAS:  
29.2 DRY BASIS (lb<sub>m</sub>/lb mole)  
27.1 WET BASIS (lb<sub>m</sub>/lb mole)
- 10) VOLUME OF GAS SAMPLED: 132.34 (acf)
- 11) AVERAGE STACK VELOCITY: 47.52 (ft/s) AVG. TEMP: 1238 (°F)  
AVERAGE VOLUMETRIC FLOW RATE: 56030 (acfm)

TABLE 111.46 FIELD DATA SUMMARY SHEET



Table 111.48: Field Sampling Data for Preliminary Test  
Canterra-Rainbow Lake, July 7, 1983  
Traverse #2



- 1) CLIENT NAME: ENERGY RESOURCES CONSERVATION BOARD  
LOCATION: Rainbow Lake  
COMPANY: Canterra Energy Limited
- 2) TEST NO: 1 DATE: July 8, 1983
- 3) PRODUCTION: Not Recorded
- 4) BAROMETRIC PRESSURE: 28.4 (inches Hg)  
STATIC PRESSURE: -0.6 (inches H<sub>2</sub>O)  
STACK DIMENSIONS: DIAMETER (D) 5 (feet)
- 5) PITOT TUBE COEFFICIENT: 0.790  
METER CORRECTION FACTOR: 1.0  
NOZZLE DIAMETER: 0.375 (inches)
- 6) GAS COMPOSITION: (percent by volume)  
CO<sub>2</sub> 3.24, O<sub>2</sub> 10.55, CO 0.0  
SO<sub>2</sub> 0.46, N<sub>2</sub> 84.73, Ar 1.02
- 7) NO. OF READINGS: 40  
TIME BETWEEN READINGS: 6.0 min.  
TEST POINTS/TRVERSE: 10  
NO. OF TRAVERSES: 2
- 8) CONDENSED WATER: 519.73 (grams)  
WATER CAUGHT BY DRYING AGENTS: 16.79 (grams)  
MOISTURE CONTENT, B<sub>wo</sub>: 0.186
- 9) MOLECULAR WEIGHT OF GAS:  
29.2 DRY BASIS (lb<sub>m</sub>/lb mole)  
27.1 WET BASIS (lb<sub>m</sub>/lb mole)
- 10) VOLUME OF GAS SAMPLED: 119.41 (acf)
- 11) AVERAGE STACK VELOCITY: 41.87 (ft/s) AVG. TEMP: 1215 (°F)  
AVERAGE VOLUMETRIC FLOW RATE: 49368 (acfm)

TABLE 111.49 FIELD DATA SUMMARY SHEET





| Sample Analysis        | Test No. 1 | Date           | July 8, 1983 | RAINBOW LAKE           |                                         |                                     |
|------------------------|------------|----------------|--------------|------------------------|-----------------------------------------|-------------------------------------|
|                        |            |                |              | Total Elemental Weight | Medium Possible Concentration<br>mg/ccf | Elemental Emission<br>Rate<br>gm/hr |
| Sample From            | PM         | Imp.<br>1,2,3, | Imp.<br>4,5  | Filter                 | Filter                                  | Filter                              |
|                        | 410.       | 1050.          | 440.         |                        |                                         |                                     |
| Volume (ml)            | 60.77      | 56400.         | —            | 75.20                  | 75.20                                   | 75.20                               |
| Total Particulate (mg) | 41.        | 42.            | 40.          | 30.                    | 150.                                    | 0.97                                |
| Fe Iron                |            |                |              |                        | 1.3                                     |                                     |

All elements except those in boxes ☐ are below the limit of detection.

Table 111.52: Summary of Incinerator Stack Source Sampling Data for Elements Whose Presence was Detected at the Canterra-Rainbow Lake Plant, Test #1



STACK NO. 1 TEST NO. 2 TRAVERSE NO. 1

| SAMPLE<br>POINT<br>(H) | TIME<br>(MIN) | STACK<br>TEMP<br>(DEG F) | DELTA P<br>(IN H2O) | VEL<br>(FT/S) | DELTA H<br>(IN H2O) | GAS METER<br>VOLUME<br>(CU FT) | PROF<br>I | TEMP<br>I | TEMP<br>O | OUTLET<br>TIME | T<br>IMPINGERS | U<br>R<br>E | S<br>GAS<br>OUT | S<br>DEG<br>F | PUMP<br>VAC<br>(IN HG) | ISOTHERMIC<br>VARIATION<br>(PERCENT) |
|------------------------|---------------|--------------------------|---------------------|---------------|---------------------|--------------------------------|-----------|-----------|-----------|----------------|----------------|-------------|-----------------|---------------|------------------------|--------------------------------------|
| 0                      | 0.00          | 5.5                      | 0.00                | 1.00          | 0.00                | 36.0                           | 0.5       | 0.00      | 0.00      | 0.00           | 0.00           | 0.00        | 0.00            | 0.00          | 0.00                   | 0.00                                 |
| 1                      | 0.05          | 5.5                      | 0.00                | 1.00          | 0.00                | 36.0                           | 0.5       | 0.00      | 0.00      | 0.00           | 0.00           | 0.00        | 0.00            | 0.00          | 0.00                   | 0.00                                 |
| 2                      | 0.10          | 5.5                      | 0.00                | 1.00          | 0.00                | 36.0                           | 0.5       | 0.00      | 0.00      | 0.00           | 0.00           | 0.00        | 0.00            | 0.00          | 0.00                   | 0.00                                 |
| 3                      | 0.15          | 5.5                      | 0.00                | 1.00          | 0.00                | 36.0                           | 0.5       | 0.00      | 0.00      | 0.00           | 0.00           | 0.00        | 0.00            | 0.00          | 0.00                   | 0.00                                 |
| 4                      | 0.20          | 5.5                      | 0.00                | 1.00          | 0.00                | 36.0                           | 0.5       | 0.00      | 0.00      | 0.00           | 0.00           | 0.00        | 0.00            | 0.00          | 0.00                   | 0.00                                 |
| 5                      | 0.25          | 5.5                      | 0.00                | 1.00          | 0.00                | 36.0                           | 0.5       | 0.00      | 0.00      | 0.00           | 0.00           | 0.00        | 0.00            | 0.00          | 0.00                   | 0.00                                 |
| 6                      | 0.30          | 5.5                      | 0.00                | 1.00          | 0.00                | 36.0                           | 0.5       | 0.00      | 0.00      | 0.00           | 0.00           | 0.00        | 0.00            | 0.00          | 0.00                   | 0.00                                 |
| 7                      | 0.35          | 5.5                      | 0.00                | 1.00          | 0.00                | 36.0                           | 0.5       | 0.00      | 0.00      | 0.00           | 0.00           | 0.00        | 0.00            | 0.00          | 0.00                   | 0.00                                 |
| 8                      | 0.40          | 5.5                      | 0.00                | 1.00          | 0.00                | 36.0                           | 0.5       | 0.00      | 0.00      | 0.00           | 0.00           | 0.00        | 0.00            | 0.00          | 0.00                   | 0.00                                 |
| 9                      | 0.45          | 5.5                      | 0.00                | 1.00          | 0.00                | 36.0                           | 0.5       | 0.00      | 0.00      | 0.00           | 0.00           | 0.00        | 0.00            | 0.00          | 0.00                   | 0.00                                 |
| 10                     | 0.50          | 5.5                      | 0.00                | 1.00          | 0.00                | 36.0                           | 0.5       | 0.00      | 0.00      | 0.00           | 0.00           | 0.00        | 0.00            | 0.00          | 0.00                   | 0.00                                 |
| 11                     | 0.55          | 5.5                      | 0.00                | 1.00          | 0.00                | 36.0                           | 0.5       | 0.00      | 0.00      | 0.00           | 0.00           | 0.00        | 0.00            | 0.00          | 0.00                   | 0.00                                 |
| 12                     | 0.60          | 5.5                      | 0.00                | 1.00          | 0.00                | 36.0                           | 0.5       | 0.00      | 0.00      | 0.00           | 0.00           | 0.00        | 0.00            | 0.00          | 0.00                   | 0.00                                 |
| 13                     | 0.65          | 5.5                      | 0.00                | 1.00          | 0.00                | 36.0                           | 0.5       | 0.00      | 0.00      | 0.00           | 0.00           | 0.00        | 0.00            | 0.00          | 0.00                   | 0.00                                 |
| 14                     | 0.70          | 5.5                      | 0.00                | 1.00          | 0.00                | 36.0                           | 0.5       | 0.00      | 0.00      | 0.00           | 0.00           | 0.00        | 0.00            | 0.00          | 0.00                   | 0.00                                 |
| 15                     | 0.75          | 5.5                      | 0.00                | 1.00          | 0.00                | 36.0                           | 0.5       | 0.00      | 0.00      | 0.00           | 0.00           | 0.00        | 0.00            | 0.00          | 0.00                   | 0.00                                 |
| 16                     | 0.80          | 5.5                      | 0.00                | 1.00          | 0.00                | 36.0                           | 0.5       | 0.00      | 0.00      | 0.00           | 0.00           | 0.00        | 0.00            | 0.00          | 0.00                   | 0.00                                 |
| 17                     | 0.85          | 5.5                      | 0.00                | 1.00          | 0.00                | 36.0                           | 0.5       | 0.00      | 0.00      | 0.00           | 0.00           | 0.00        | 0.00            | 0.00          | 0.00                   | 0.00                                 |
| 18                     | 0.90          | 5.5                      | 0.00                | 1.00          | 0.00                | 36.0                           | 0.5       | 0.00      | 0.00      | 0.00           | 0.00           | 0.00        | 0.00            | 0.00          | 0.00                   | 0.00                                 |
| 19                     | 0.95          | 5.5                      | 0.00                | 1.00          | 0.00                | 36.0                           | 0.5       | 0.00      | 0.00      | 0.00           | 0.00           | 0.00        | 0.00            | 0.00          | 0.00                   | 0.00                                 |
| 20                     | 1.00          | 5.5                      | 0.00                | 1.00          | 0.00                | 36.0                           | 0.5       | 0.00      | 0.00      | 0.00           | 0.00           | 0.00        | 0.00            | 0.00          | 0.00                   | 0.00                                 |

Table III.54: Field Sampling Data for Test #2  
Canterra-Rainbow Lake, July 9, 1983  
Traverse #1





ALL elements except those in boxes ☐ are below the limit of detection.

**Table 111.56: Summary of Incinerator Stack Source Sampling Data for Elements Whose Presence was Detected at the Canterra-Rainbow Lake Plant Test #2**

- 1) CLIENT NAME: ENERGY RESOURCES CONSERVATION BOARD  
LOCATION: Rainbow Lake  
COMPANY: Canterra Energy Limited
- 2) TEST NO: 3 DATE: July 10, 1983
- 3) PRODUCTION: Not Recorded
- 4) BAROMETRIC PRESSURE: 28.2 (inches Hg)  
STATIC PRESSURE: -0.6 (inches H<sub>2</sub>O)  
STACK DIMENSIONS: DIAMETER (D) 5 (feet)
- 5) PITOT TUBE COEFFICIENT: 0.790  
METER CORRECTION FACTOR: 1.0  
NOZZLE DIAMETER: 0.375 (inches)
- 6) GAS COMPOSITION: (percent by volume)  
CO<sub>2</sub> 3.04, O<sub>2</sub> 18.24, CO 0.0  
SO<sub>2</sub> 0.49, N<sub>2</sub> 77.30, Ar 0.93
- 7) NO. OF READINGS: 40  
TIME BETWEEN READINGS: 6.0 min.  
TEST POINTS/TRVERSE: 10  
NO. OF TRAVERSES: 2
- 8) CONDENSED WATER: 499.84 (grams)  
WATER CAUGHT BY DRYING AGENTS: 11.99 (grams)  
MOISTURE CONTENT, B<sub>wo</sub>: 0.173
- 9) MOLECULAR WEIGHT OF GAS;  
29.5 DRY BASIS (lb<sub>m</sub>/lb mole)  
27.5 WET BASIS (lb<sub>m</sub>/lb mole)
- 10) VOLUME OF GAS SAMPLED: 128.84 (acf)
- 11) AVERAGE STACK VELOCITY: 42.32 (ft/s) AVG. TEMP: 1214 (°F)  
AVERAGE VOLUMETRIC FLOW RATE: 49900 (acfm)

TABLE 111.57 FIELD DATA SUMMARY SHEET

STACK NO. 1 Y 1 M. 3 INVERSE NO. 1

[illegible]

Table 111.58: Field Sampling Data for Test #3  
Canterra-Rainbow Lake, July 10, 1983  
Traverse #1



| Sample Analyses         | Test No. 3 | Date   | July 10, 1963 | RAINBOW LAKE |                                             |                                             |
|-------------------------|------------|--------|---------------|--------------|---------------------------------------------|---------------------------------------------|
|                         |            |        |               | Micrograms   | Total Elemental Weight ug                   | Maximum Possible Elemental Oxidation ug/mcf |
| Sample From             | DPH        | DPH    | DPH           |              |                                             |                                             |
|                         | 1,2,3      | 4,5    |               |              |                                             |                                             |
| Volume (ml)             | 470.       | 870.   | 320.          |              | $\Sigma = 8.1 \times 10^3$ ug/d (total)     |                                             |
| Total Particulates (ug) | 58.64      | 52628. | —             | 75.29        | $\Sigma = 2.0 \times 10^3$ ug/d (front end) |                                             |
| Aluminum                | 140.       | 3900.  | 96.           | 50.          | 4200.                                       | 36.                                         |
| Cr Chromium             | 28.        | 35.    | 22.           | 20.          | 95.                                         | 0.82                                        |
| Fe Iron                 | 94.        | 150.   | 32.           | 20.          | 300.                                        | 2.6                                         |
| Zn Zinc                 | 4.2        | 4.4    | 3.2           | 3.0          | 15.                                         | 0.13                                        |

All elements except those in boxes ☐ are below the limit of detection.

Table 111.60: Summary of Incinerator Stack Source Sampling Data for Elements Whose Presence was Detected at the Canterra-Rainbow Lake Plant, Test #3

- 1) CLIENT NAME: ENERGY RESOURCES CONSERVATION BOARD  
LOCATION: Quirk Creek  
COMPANY: ESSO Resources Canada Ltd.
- 2) TEST NO: 1                      DATE: November 23, 1983
- 3) PRODUCTION:  $1.03 \times 10^6 \text{ m}^3/\text{d}$  Sales Gas
- 4) BAROMETRIC PRESSURE: 25.330                      (inches Hg)  
STATIC PRESSURE: -2.1                      (inches H<sub>2</sub>O)  
STACK DIMENSIONS: DIAMETER (D) 5  $\frac{5}{6}$  (feet)
- 5) PITOT TUBE COEFFICIENT: 0.795  
METER CORRECTION FACTOR: 1.0  
NOZZLE DIAMETER: 0.3125                      (inches)
- 6) GAS COMPOSITION: (percent by volume)  
 $\text{CO}_2$  4.80,       $\text{O}_2$  9.32,      CO 0.0  
 $\text{SO}_2$  0.35,       $\text{N}_2$  84.51,      Ar 1.02
- 7) NO. OF READINGS: 40  
TIME BETWEEN READINGS: 3.0 min.  
TEST POINTS/TRVERSE: 10  
NO. OF TRAVERSES: 2
- 8) CONDENSED WATER: 328.06                      (grams)  
WATER CAUGHT BY DRYING AGENTS: 9.95 (grams)  
MOISTURE CONTENT,  $B_{wo}$ : 0.160
- 9) MOLECULAR WEIGHT OF GAS:  
29.4 DRY BASIS (lb<sub>m</sub>/lb mole)  
27.6 WET BASIS (lb<sub>m</sub>/lb mole)
- 10) VOLUME OF GAS SAMPLED: 95.27                      (acf)
- 11) AVERAGE STACK VELOCITY: 79.92                      (ft/s) AVG. TEMP: 929 (°F)  
AVERAGE VOLUMETRIC FLOW RATE: 128179 (acfm)

TABLE 111.61 FIELD DATA SUMMARY SHEET

| STACK NO.         | TEST NO.   | TRAVERSE NO.     | DELTA H  | DELTA P  | VEL    | GAS METER VOLUME | PRUBE    | TEMP     | OVEN     | A        | Y        | U        | H        | E        | S        | GAS METER | PUMP VAC | ISOMETRIC VARIATION |
|-------------------|------------|------------------|----------|----------|--------|------------------|----------|----------|----------|----------|----------|----------|----------|----------|----------|-----------|----------|---------------------|
| SAMPLE POINT (NO) | TIME (MIN) | STACK TEMP DEG.F | (IN H2O) | (IN H2O) | (FT/S) | (CUFT)           | (IN H2O) | (IN H2O) | (IN H2O) | (IN H2O) | (IN H2O) | (IN H2O) | (IN H2O) | (IN H2O) | (IN H2O) | (IN H2O)  | (IN H2O) | (PERCENT)           |
| 0                 | 0          | 925              | 0.550    | 1.36     | 71.07  | 315.07           | 415      | 285      | 35       | 75       | 35       | 35       | 35       | 35       | 35       | 35        | 3.00     | 0.00                |
| 1                 | 3          | 925              | 0.550    | 1.36     | 71.07  | 315.07           | 415      | 285      | 35       | 75       | 35       | 35       | 35       | 35       | 35       | 35        | 3.00     | 103.77              |
| 2                 | 6          | 925              | 0.600    | 1.48     | 74.23  | 315.75           | 415      | 285      | 35       | 75       | 35       | 35       | 35       | 35       | 35       | 35        | 3.00     | 93.43               |
| 3                 | 9          | 925              | 0.600    | 1.48     | 74.23  | 315.75           | 415      | 285      | 35       | 75       | 35       | 35       | 35       | 35       | 35       | 35        | 3.00     | 59.27               |
| 4                 | 12         | 925              | 0.650    | 1.60     | 77.27  | 324.05           | 415      | 285      | 35       | 75       | 35       | 35       | 35       | 35       | 35       | 35        | 3.00     | 48.35               |
| 5                 | 15         | 925              | 0.650    | 1.60     | 77.27  | 324.05           | 415      | 285      | 35       | 75       | 35       | 35       | 35       | 35       | 35       | 35        | 3.00     | 92.33               |
| 6                 | 18         | 925              | 0.700    | 1.87     | 80.18  | 326.11           | 415      | 285      | 35       | 75       | 35       | 35       | 35       | 35       | 35       | 35        | 3.00     | 55.39               |
| 7                 | 21         | 925              | 0.750    | 1.90     | 83.15  | 330.30           | 415      | 285      | 35       | 75       | 35       | 35       | 35       | 35       | 35       | 35        | 3.00     | 103.47              |
| 8                 | 24         | 925              | 0.750    | 1.90     | 83.15  | 330.30           | 415      | 285      | 35       | 75       | 35       | 35       | 35       | 35       | 35       | 35        | 3.00     | 95.23               |
| 9                 | 27         | 925              | 0.750    | 1.90     | 83.15  | 330.30           | 415      | 285      | 35       | 75       | 35       | 35       | 35       | 35       | 35       | 35        | 3.00     | 102.62              |
| 10                | 30         | 925              | 0.800    | 1.83     | 86.03  | 338.26           | 415      | 285      | 35       | 75       | 35       | 35       | 35       | 35       | 35       | 35        | 3.00     | 106.55              |
| 11                | 33         | 925              | 0.800    | 1.94     | 86.03  | 340.42           | 415      | 285      | 35       | 75       | 35       | 35       | 35       | 35       | 35       | 35        | 3.00     | 102.22              |
| 12                | 36         | 925              | 0.800    | 1.94     | 86.03  | 340.42           | 415      | 285      | 35       | 75       | 35       | 35       | 35       | 35       | 35       | 35        | 3.00     | 102.32              |
| 13                | 39         | 925              | 0.800    | 1.94     | 86.03  | 340.42           | 415      | 285      | 35       | 75       | 35       | 35       | 35       | 35       | 35       | 35        | 3.00     | 96.23               |
| 14                | 42         | 925              | 0.800    | 1.94     | 86.03  | 340.42           | 415      | 285      | 35       | 75       | 35       | 35       | 35       | 35       | 35       | 35        | 3.00     | 100.91              |
| 15                | 45         | 925              | 0.770    | 1.96     | 84.40  | 348.79           | 415      | 285      | 35       | 75       | 35       | 35       | 35       | 35       | 35       | 35        | 3.00     | 104.10              |
| 16                | 48         | 925              | 0.750    | 1.96     | 83.10  | 353.83           | 415      | 285      | 35       | 75       | 35       | 35       | 35       | 35       | 35       | 35        | 3.00     | 106.96              |
| 17                | 51         | 925              | 0.750    | 1.96     | 83.10  | 353.83           | 415      | 285      | 35       | 75       | 35       | 35       | 35       | 35       | 35       | 35        | 3.00     | 102.35              |
| 18                | 54         | 925              | 0.650    | 1.67     | 77.41  | 357.95           | 415      | 285      | 35       | 75       | 35       | 35       | 35       | 35       | 35       | 35        | 3.00     | 102.49              |
| 19                | 57         | 925              | 0.650    | 1.54     | 74.23  | 360.15           | 415      | 285      | 35       | 75       | 35       | 35       | 35       | 35       | 35       | 35        | 3.00     | 97.26               |
| 20                | 60         | 925              | 0.600    | 1.54     | 74.23  | 360.15           | 415      | 285      | 35       | 75       | 35       | 35       | 35       | 35       | 35       | 35        | 3.00     | 97.26               |

Table 111.62: Field Sampling Data for Test #1  
Esso-Quirk Creek, November 23, 1983  
Traverse #1



| STACK NO. 1       |            | TEST NO. 1       |                  | TRAVERSE NO. 2 |                  |                          |       |             |                |                   |                  |                                |        |  |  |  |  |
|-------------------|------------|------------------|------------------|----------------|------------------|--------------------------|-------|-------------|----------------|-------------------|------------------|--------------------------------|--------|--|--|--|--|
| SAMPLE POINT (NO) | TIME (MIN) | STACK TEMP DEG.F | DELTA P (IN H2O) | VEL (FT/S)     | DELTA H (IN H2O) | GAS METER VOLUME (CU FT) | PRUDE | TEMP (OVEN) | OUTLET (INLET) | T U R E S (DEG.F) | PUMP VAC (IN HG) | ISURINETIC VARIATION (PERCENT) |        |  |  |  |  |
| 0                 | 0          | 925              | 0.600            | 74.23          | 1.55             | 862.34                   | 415   | 285         | 50             | 110               | 55               | 3.50                           | 0.00   |  |  |  |  |
| 1                 | 3          | 925              | 0.600            | 74.23          | 1.55             | 862.09                   | 415   | 285         | 50             | 110               | 55               | 3.50                           | 106.64 |  |  |  |  |
| 2                 | 6          | 925              | 0.620            | 77.27          | 1.68             | 866.91                   | 415   | 285         | 50             | 110               | 55               | 4.00                           | 97.03  |  |  |  |  |
| 3                 | 9          | 925              | 0.650            | 77.27          | 1.80             | 869.30                   | 415   | 285         | 50             | 110               | 55               | 4.50                           | 104.46 |  |  |  |  |
| 4                 | 12         | 925              | 0.700            | 80.16          | 1.80             | 871.59                   | 415   | 285         | 50             | 115               | 55               | 5.00                           | 100.15 |  |  |  |  |
| 5                 | 15         | 930              | 0.750            | 83.15          | 1.93             | 874.14                   | 415   | 285         | 50             | 120               | 55               | 5.00                           | 107.52 |  |  |  |  |
| 6                 | 18         | 930              | 0.750            | 83.15          | 1.93             | 876.50                   | 415   | 285         | 50             | 120               | 55               | 5.00                           | 101.99 |  |  |  |  |
| 7                 | 21         | 930              | 0.750            | 83.15          | 1.93             | 881.32                   | 415   | 285         | 45             | 130               | 60               | 5.00                           | 95.73  |  |  |  |  |
| 8                 | 24         | 930              | 0.750            | 83.15          | 1.95             | 883.89                   | 415   | 285         | 45             | 130               | 60               | 5.00                           | 102.42 |  |  |  |  |
| 9                 | 27         | 930              | 0.750            | 83.30          | 1.95             | 886.42                   | 415   | 285         | 45             | 130               | 60               | 5.00                           | 104.94 |  |  |  |  |
| 10                | 30         | 935              | 0.750            | 83.30          | 1.95             | 888.78                   | 415   | 285         | 45             | 130               | 60               | 5.00                           | 107.49 |  |  |  |  |
| 11                | 33         | 935              | 0.770            | 84.40          | 1.95             | 891.41                   | 415   | 285         | 45             | 130               | 60               | 5.00                           | 102.51 |  |  |  |  |
| 12                | 36         | 935              | 0.770            | 84.40          | 1.95             | 894.11                   | 415   | 285         | 45             | 130               | 60               | 5.00                           | 103.79 |  |  |  |  |
| 13                | 39         | 935              | 0.770            | 84.40          | 1.95             | 896.80                   | 415   | 285         | 45             | 130               | 60               | 5.00                           | 101.43 |  |  |  |  |
| 14                | 42         | 935              | 0.750            | 83.30          | 1.95             | 899.50                   | 415   | 285         | 45             | 130               | 60               | 5.00                           | 101.43 |  |  |  |  |
| 15                | 45         | 935              | 0.680            | 79.17          | 1.69             | 903.79                   | 415   | 285         | 45             | 130               | 60               | 5.00                           | 100.46 |  |  |  |  |
| 16                | 48         | 930              | 0.680            | 77.41          | 1.62             | 906.21                   | 415   | 285         | 45             | 130               | 60               | 4.50                           | 105.07 |  |  |  |  |
| 17                | 51         | 930              | 0.650            | 77.41          | 1.62             | 908.50                   | 415   | 285         | 45             | 130               | 60               | 4.50                           | 99.11  |  |  |  |  |
| 18                | 54         | 930              | 0.650            | 77.27          | 1.62             | 908.50                   | 415   | 285         | 45             | 130               | 60               | 4.50                           | 105.79 |  |  |  |  |
| 19                | 57         | 925              | 0.650            | 77.27          | 1.62             | 910.74                   | 415   | 285         | 45             | 130               | 60               | 4.50                           | 105.79 |  |  |  |  |
| 20                | 60         | 925              | 0.650            | 77.27          | 1.62             | 910.74                   | 415   | 285         | 45             | 130               | 60               | 4.50                           | 105.79 |  |  |  |  |

Table 111.63: Field Sampling Data for Test #1  
Esso-Quirk Creek, November 23, 1983  
Traverse #2

| Sample Analysis        | Test No. 1    | Date   | November 23, 1963 | QUIRK CREEK                                  |                                                  |
|------------------------|---------------|--------|-------------------|----------------------------------------------|--------------------------------------------------|
|                        |               |        |                   | Maximum Possible                             |                                                  |
|                        | Micrograms    |        |                   | Elemental Concentration                      | Elemental Emission Rate                          |
| Sample From            | DPG. 1,2,3, 4 | DPG. 5 | Filter            | µg/pcf                                       | g/hr                                             |
| Volume (ml)            | 1215.         | 160.   | 160.              | $E_R = 1.8 \times 10^4 \text{ kg/d (total)}$ |                                                  |
| Total Particulate (mg) | 104.8         | 29548. | —                 | 48.53                                        | $E_R = 9.1 \times 10^3 \text{ kg/d (front end)}$ |
| Cd Cadmium             | 3.0           | 6.7    | 3.2               | 3.2                                          | 2.0                                              |
| Cu Chromium            | 30.           | 33.    | 32.               | 32.                                          | 20.                                              |
| Cu Copper              | 15.           | 45.    | 16.               | 16.                                          | 10.                                              |
| Fe Iron                | 30.           | 120.   | 16.               | 16.                                          | 40.                                              |
| Hg Mercury             | 1.4           | 1.1    | 1.6               | 1.6                                          | 680.                                             |
| Zn Zinc                | 23.           | 12.    | 4.8               | 35.                                          | 2.0                                              |

All elements except those in boxes are below the limit of detection.

Table 111.64: Summary of Incinerator Stack Source Sampling Data for Elements Whose Presence was Detected at the Esso-Quirk Creek Plant, Test #1

- 1) CLIENT NAME: ENERGY RESOURCES CONSERVATION BOARD  
LOCATION: Quirk Creek  
COMPANY: ESSO Resources Canada Ltd.
- 2) TEST NO: 2 DATE: November 24, 1983
- 3) PRODUCTION:  $1.03 \times 10^6$  m<sup>3</sup>/d Sales Gas
- 4) BAROMETRIC PRESSURE: 25.27 (inches Hg)  
STATIC PRESSURE: -2.1 (inches H<sub>2</sub>O)  
STACK DIMENSIONS: DIAMETER (D) 5 5/6 (feet)
- 5) PITOT TUBE COEFFICIENT: 0.795  
METER CORRECTION FACTOR: 1.0  
NOZZLE DIAMETER: 0.3125 (inches)
- 6) GAS COMPOSITION: (percent by volume)  
CO<sub>2</sub> 4.28, O<sub>2</sub> 8.60, CO 0.0  
SO<sub>2</sub> 0.34, N<sub>2</sub> 85.75, Ar 1.03
- 7) NO. OF READINGS: 40  
TIME BETWEEN READINGS: 3 min.  
TEST POINTS/TRVERSE: 10  
NO. OF TRAVERSES: 2
- 8) CONDENSED WATER: 351.42 (grams)  
WATER CAUGHT BY DRYING AGENTS: 12.61 (grams)  
MOISTURE CONTENT, B<sub>wo</sub>: 0.176
- 9) MOLECULAR WEIGHT OF GAS:  
29.3 DRY BASIS (lb<sub>m</sub>/lb mole)  
27.3 WET BASIS (lb<sub>m</sub>/lb mole)
- 10) VOLUME OF GAS SAMPLED: 91.51 (acf)
- 11) AVERAGE STACK VELOCITY: 79.46 (ft/s) AVG. TEMP: 919(°F)  
AVERAGE VOLUMETRIC FLOW RATE: 127443 (acfm)

TABLE 111.65 FIELD DATA SUMMARY SHEET

STACK NO. 1 TEST NO. 2 TRAVERSE NO. 1

| SAMPLE<br>POINT<br>(NO) | TIME<br>(MIN) | STACK<br>TEMP<br>DEG.F | DELTA P<br>(IN H2O) | VEL<br>(FT/S) | DELTA H<br>(IN H2O) | GAS METER<br>VOLUME<br>(CU FT) | PROBE | TEMP<br>I | TEMP<br>O | R A<br>OUTLET | Y U B<br>IMPIGERS | E S<br>IDEG.F | GAS<br>HELM | PUMP<br>VAC<br>(IN H2) | ISUKINETIC<br>VARIATION<br>(PERCENT) |
|-------------------------|---------------|------------------------|---------------------|---------------|---------------------|--------------------------------|-------|-----------|-----------|---------------|-------------------|---------------|-------------|------------------------|--------------------------------------|
| 0                       | 0             | 910                    | 0.580               | 73.04         | 1.35                | 403.82                         | 415   | 200       | 35        | 90            | 40                | 40            | 40          | 1.00                   | 0.00                                 |
| 1                       | 3             | 910                    | 0.580               | 73.04         | 1.35                | 403.82                         | 415   | 200       | 35        | 90            | 40                | 40            | 40          | 1.00                   | 94.68                                |
| 2                       | 6             | 910                    | 0.580               | 74.29         | 1.48                | 407.53                         | 415   | 265       | 35        | 110           | 45                | 45            | 45          | 3.50                   | 95.39                                |
| 3                       | 9             | 910                    | 0.600               | 74.29         | 1.48                | 410.12                         | 415   | 270       | 35        | 115           | 45                | 45            | 45          | 3.50                   | 107.28                               |
| 4                       | 12            | 910                    | 0.650               | 77.46         | 1.53                | 412.16                         | 415   | 270       | 35        | 125           | 45                | 45            | 45          | 4.00                   | 102.05                               |
| 5                       | 15            | 910                    | 0.650               | 77.46         | 1.53                | 414.03                         | 415   | 280       | 35        | 125           | 45                | 45            | 45          | 4.00                   | 102.39                               |
| 6                       | 18            | 910                    | 0.700               | 80.53         | 1.66                | 416.77                         | 415   | 280       | 35        | 135           | 50                | 50            | 50          | 4.50                   | 96.40                                |
| 7                       | 21            | 910                    | 0.700               | 80.53         | 1.66                | 419.02                         | 415   | 280       | 35        | 135           | 50                | 50            | 50          | 4.50                   | 96.75                                |
| 8                       | 24            | 910                    | 0.770               | 84.62         | 1.82                | 421.40                         | 415   | 280       | 35        | 145           | 50                | 50            | 50          | 5.00                   | 102.35                               |
| 9                       | 27            | 910                    | 0.770               | 84.62         | 1.82                | 424.10                         | 415   | 280       | 35        | 145           | 50                | 50            | 50          | 5.00                   | 107.70                               |
| 10                      | 30            | 910                    | 0.770               | 84.62         | 1.82                | 426.43                         | 415   | 290       | 35        | 155           | 55                | 55            | 55          | 5.00                   | 95.71                                |
| 11                      | 33            | 910                    | 0.770               | 84.62         | 1.82                | 428.90                         | 415   | 290       | 35        | 155           | 55                | 55            | 55          | 5.00                   | 100.90                               |
| 12                      | 36            | 910                    | 0.770               | 84.62         | 1.82                | 431.25                         | 415   | 290       | 35        | 165           | 55                | 55            | 55          | 5.00                   | 96.55                                |
| 13                      | 39            | 910                    | 0.720               | 81.97         | 1.70                | 433.50                         | 415   | 290       | 35        | 165           | 55                | 55            | 55          | 5.00                   | 95.20                                |
| 14                      | 42            | 910                    | 0.720               | 81.97         | 1.70                | 435.92                         | 415   | 290       | 35        | 165           | 55                | 55            | 55          | 5.00                   | 102.31                               |
| 15                      | 45            | 910                    | 0.720               | 81.97         | 1.70                | 438.22                         | 415   | 290       | 35        | 165           | 55                | 55            | 55          | 5.00                   | 95.94                                |
| 16                      | 48            | 910                    | 0.720               | 81.97         | 1.70                | 440.41                         | 415   | 290       | 35        | 165           | 55                | 55            | 55          | 5.00                   | 97.81                                |
| 17                      | 51            | 910                    | 0.650               | 77.60         | 1.55                | 442.84                         | 415   | 300       | 40        | 160           | 55                | 55            | 55          | 4.00                   | 107.87                               |
| 18                      | 54            | 910                    | 0.650               | 77.60         | 1.55                | 445.10                         | 415   | 300       | 40        | 160           | 55                | 55            | 55          | 4.00                   | 100.19                               |
| 19                      | 57            | 910                    | 0.650               | 77.60         | 1.55                | 447.25                         | 415   | 300       | 40        | 160           | 55                | 55            | 55          | 4.00                   | 99.12                                |
| 20                      | 60            | 910                    | 0.600               | 74.42         | 1.44                | 449.49                         | 415   | 300       | 40        | 160           | 55                | 55            | 55          | 4.00                   | 102.95                               |

Table 111.66: Field Sampling Data for Test #2  
Esso-Quirk Creek, November 24, 1983  
Traverse #1

| STACK NO.         | 1          | TEST NO.         | 2                | TRAVERSE NO. | 2                |                          |       |           |              |                     |               |           |                  |                                |  |
|-------------------|------------|------------------|------------------|--------------|------------------|--------------------------|-------|-----------|--------------|---------------------|---------------|-----------|------------------|--------------------------------|--|
| SAMPLE POINT (NO) | TIME (MIN) | STACK TEMP DEG.F | DELTA P (IN H2O) | VEL (FT/SEC) | DELTA H (IN H2O) | GAS METER VOLUME (CU FT) | PROBE | TEMP OVER | WATER OUTLET | AIR IMPINGERS INLET | GAS METER OUT | S (DEG.F) | PUMP VAC (IN HG) | ISOKINETIC VARIATION (PERCENT) |  |
| 0                 | 9          | 910              | 0.550            | 71.13        | 1.31             | 949.49                   | 415   | 295       | 35           | 95                  | 50            | 50        | 3.50             | 6.00                           |  |
| 1                 | 9          | 910              | 0.550            | 71.13        | 1.31             | 951.32                   | 415   | 295       | 40           | 130                 | 50            | 50        | 3.50             | 98.22                          |  |
| 2                 | 9          | 910              | 0.600            | 74.29        | 1.43             | 953.57                   | 415   | 295       | 40           | 140                 | 50            | 50        | 4.00             | 95.76                          |  |
| 3                 | 9          | 910              | 0.650            | 77.46        | 1.55             | 955.57                   | 415   | 295       | 40           | 140                 | 50            | 50        | 4.50             | 95.26                          |  |
| 4                 | 12         | 915              | 0.650            | 77.46        | 1.55             | 957.82                   | 415   | 295       | 40           | 145                 | 50            | 50        | 4.50             | 102.58                         |  |
| 5                 | 15         | 915              | 0.650            | 77.46        | 1.55             | 960.13                   | 415   | 295       | 40           | 150                 | 50            | 50        | 4.50             | 102.66                         |  |
| 6                 | 18         | 915              | 0.700            | 80.39        | 1.67             | 962.34                   | 415   | 295       | 40           | 155                 | 50            | 50        | 4.50             | 94.74                          |  |
| 7                 | 21         | 915              | 0.700            | 80.39        | 1.67             | 964.49                   | 415   | 295       | 40           | 155                 | 50            | 50        | 5.00             | 92.47                          |  |
| 8                 | 24         | 920              | 0.750            | 83.36        | 1.78             | 966.75                   | 415   | 295       | 45           | 160                 | 50            | 50        | 5.00             | 102.08                         |  |
| 9                 | 27         | 920              | 0.750            | 83.36        | 1.75             | 969.16                   | 415   | 295       | 45           | 160                 | 50            | 50        | 5.00             | 100.28                         |  |
| 10                | 30         | 925              | 0.750            | 83.51        | 1.75             | 971.74                   | 415   | 295       | 45           | 160                 | 50            | 50        | 5.00             | 98.96                          |  |
| 11                | 33         | 925              | 0.750            | 83.51        | 1.75             | 974.32                   | 415   | 295       | 45           | 160                 | 50            | 50        | 5.00             | 107.26                         |  |
| 12                | 36         | 925              | 0.770            | 84.62        | 1.80             | 976.87                   | 415   | 295       | 45           | 165                 | 50            | 50        | 5.00             | 104.85                         |  |
| 13                | 39         | 925              | 0.770            | 84.62        | 1.80             | 979.20                   | 415   | 295       | 45           | 165                 | 50            | 50        | 5.00             | 95.73                          |  |
| 14                | 42         | 925              | 0.750            | 83.51        | 1.80             | 981.48                   | 415   | 295       | 45           | 170                 | 50            | 55        | 5.00             | 94.68                          |  |
| 15                | 45         | 925              | 0.750            | 83.51        | 1.80             | 983.79                   | 415   | 295       | 45           | 170                 | 50            | 55        | 5.00             | 103.34                         |  |
| 16                | 48         | 920              | 0.700            | 80.53        | 1.66             | 986.78                   | 415   | 295       | 55           | 160                 | 50            | 50        | 4.50             | 95.76                          |  |
| 17                | 51         | 920              | 0.700            | 80.53        | 1.66             | 991.06                   | 415   | 295       | 55           | 160                 | 50            | 50        | 4.50             | 107.24                         |  |
| 18                | 54         | 915              | 0.630            | 79.23        | 1.65             | 993.33                   | 415   | 295       | 55           | 160                 | 50            | 50        | 4.00             | 99.42                          |  |
| 19                | 57         | 915              | 0.650            | 77.46        | 1.60             | 995.33                   | 415   | 295       | 55           | 160                 | 50            | 50        | 4.00             | 93.38                          |  |
| 20                | 60         | 915              | 0.650            | 77.46        | 1.60             | 995.33                   | 415   | 295       | 55           | 160                 | 50            | 50        | 4.00             | 95.86                          |  |

Table 111.67: Field Sampling Data for Test #2  
Esso-Quirk Creek, November 24, 1983  
Traverse #2

| Sample Analysis         | Test No. 2 | Date          | November 26, 1963 | QUIRK CREEK                                     |                                          |                           |      |      |
|-------------------------|------------|---------------|-------------------|-------------------------------------------------|------------------------------------------|---------------------------|------|------|
| Sample Form             | Micrograms |               |                   | Maximum Possible Elemental Concentration mg/mcf | Elemental Emission Rate gm/hr            |                           |      |      |
|                         | PM         | DSP. 1,2,3, 4 | DSP. 5            |                                                 |                                          | Total Elemental Weight mg |      |      |
| Volume (ml)             | 320.       | 1155.         | 230.              | 120.                                            | $E_R = 1.9 \times 10^4$ kg/d (total)     |                           |      |      |
| Total Particulates (mg) | 57.52      | 31060.        | —                 | 25.65                                           | $E_R = 5.0 \times 10^1$ kg/d (front end) |                           |      |      |
| Cr Chromium             | 32.        | 42.           | 23.               | 24.                                             | 20.                                      | 140.                      | 1.7  | 3.5  |
| Fe Iron                 | 16.        | 42.           | 12.               | 12.                                             | 20.                                      | 100.                      | 1.3  | 2.6  |
| Sr Strontium            | 9.6        | 5.3           | 6.9               | 6.0                                             | 8.0                                      | 36.                       | 0.44 | 0.91 |
| Zn Zinc                 | 6.4        | 3.2           | 6.9               | 3.6                                             | 2.0                                      | 22.                       | 0.27 | 0.55 |

All elements except those in boxes ☐ are below the limit of detection.

Table III.68: Summary of Incinerator Stack Source Sampling  
Data for Elements Whose Presence was Detected  
at the Esso-Quirk Creek Plant, Test #2

- 1) CLIENT NAME: ENERGY RESOURCES CONSERVATION BOARD  
LOCATION: Quirk Creek  
COMPANY: ESSO Resources Canada Ltd.
- 2) TEST NO: 3 DATE: November 25, 1983
- 3) PRODUCTION:  $1.07 \times 10^6 \text{ m}^3/\text{d}$  Sales Gas
- 4) BAROMETRIC PRESSURE: 25.60 (inches Hg)  
STATIC PRESSURE: -2.1 (inches H<sub>2</sub>O)  
STACK DIMENSIONS: DIAMETER (D) 5 5/6 (feet)
- 5) PITOT TUBE COEFFICIENT: 0.795  
METER CORRECTION FACTOR: 1.0  
NOZZLE DIAMETER: 0.3125 (inches)
- 6) GAS COMPOSITION: (percent by volume)  
CO<sub>2</sub> 4.36, O<sub>2</sub> 8.25, CO 0.0  
SO<sub>2</sub> 0.34, N<sub>2</sub> 86.01, Ar 1.04
- 7) NO. OF READINGS: 40  
TIME BETWEEN READINGS: 3 min.  
TEST POINTS/TRVERSE: 10  
NO. OF TRAVERSES: 2
- 8) CONDENSED WATER: 302.15 (grams)  
WATER CAUGHT BY DRYING AGENTS: 10.79 (grams)  
MOISTURE CONTENT, B<sub>wo</sub>: 0.153
- 9) MOLECULAR WEIGHT OF GAS:  
29.3 DRY BASIS (lb<sub>m</sub>/lb mole)  
27.6 WET BASIS (lb<sub>m</sub>/lb mole)
- 10) VOLUME OF GAS SAMPLED: 90.74 (acf)
- 11) AVERAGE STACK VELOCITY: 77.79 (ft/s) AVG. TEMP: 912 (°F)  
AVERAGE VOLUMETRIC FLOW RATE: 124751 (acfm)
- TABLE 111.69 FIELD DATA SUMMARY SHEET



| STACK NO.          | 1          | TEST NO.            | 3                             | TRAVERSE NO. | 1                             |                          |       |             |            |                   |            |                  |                                |                               |  |
|--------------------|------------|---------------------|-------------------------------|--------------|-------------------------------|--------------------------|-------|-------------|------------|-------------------|------------|------------------|--------------------------------|-------------------------------|--|
| SAMPLE POINT (NO.) | TIME (MIN) | STACK TEMP (DEG. F) | DELTA P (IN H <sub>2</sub> O) | VEL (FT/S)   | DELTA H (IN H <sub>2</sub> O) | GAS METER VOLUME (CU FT) | PROBE | TEMP (OVEN) | AIR OUTLET | IMPINGERS (INLET) | GAS OUTLET | DELTA T (DEG. F) | PUMP VAC (IN H <sub>2</sub> O) | ISOMETRIC VARIATION (PERCENT) |  |
| 0                  |            | 905                 | 0.600                         | 73.32        | 1.32                          | 990.38                   | 415   | 270         |            | 10                | 90         | 35               | 3.00                           | 92.09                         |  |
| 1                  | 3          | 905                 | 0.600                         | 73.32        | 1.32                          | 992.47                   | 415   | 270         |            | 30                | 100        | 35               | 3.00                           | 92.77                         |  |
| 2                  | 6          | 905                 | 0.600                         | 73.32        | 1.44                          | 994.60                   | 415   | 270         |            | 30                | 100        | 35               | 4.00                           | 92.53                         |  |
| 3                  | 12         | 910                 | 0.620                         | 74.67        | 1.45                          | 996.57                   | 415   | 280         |            | 30                | 110        | 35               | 4.00                           | 92.16                         |  |
| 4                  | 15         | 910                 | 0.620                         | 74.67        | 1.45                          | 998.70                   | 415   | 285         |            | 30                | 120        | 40               | 4.00                           | 92.09                         |  |
| 5                  | 18         | 910                 | 0.650                         | 76.95        | 1.52                          | 1000.99                  | 415   | 290         |            | 30                | 120        | 40               | 4.00                           | 92.84                         |  |
| 6                  | 21         | 915                 | 0.720                         | 80.41        | 1.52                          | 1003.10                  | 415   | 290         |            | 30                | 130        | 40               | 4.00                           | 92.51                         |  |
| 7                  | 24         | 915                 | 0.720                         | 80.41        | 1.68                          | 1005.54                  | 415   | 300         |            | 30                | 140        | 40               | 4.00                           | 92.30                         |  |
| 8                  | 27         | 915                 | 0.770                         | 83.36        | 1.79                          | 1007.28                  | 415   | 300         |            | 35                | 150        | 40               | 4.50                           | 92.24                         |  |
| 9                  | 30         | 915                 | 0.770                         | 83.36        | 1.79                          | 1010.67                  | 415   | 300         |            | 35                | 150        | 40               | 4.50                           | 92.09                         |  |
| 10                 | 33         | 915                 | 0.770                         | 83.36        | 1.79                          | 1012.19                  | 415   | 300         |            | 35                | 155        | 40               | 4.50                           | 92.27                         |  |
| 11                 | 36         | 920                 | 0.720                         | 80.76        | 1.67                          | 1015.36                  | 415   | 300         |            | 35                | 155        | 40               | 4.50                           | 92.29                         |  |
| 12                 | 39         | 920                 | 0.720                         | 80.76        | 1.67                          | 1018.45                  | 415   | 300         |            | 35                | 160        | 40               | 4.00                           | 92.99                         |  |
| 13                 | 42         | 915                 | 0.720                         | 80.76        | 1.67                          | 1021.14                  | 415   | 300         |            | 35                | 160        | 40               | 4.00                           | 92.91                         |  |
| 14                 | 45         | 915                 | 0.720                         | 80.61        | 1.63                          | 1024.45                  | 415   | 300         |            | 35                | 160        | 40               | 4.00                           | 92.57                         |  |
| 15                 | 48         | 910                 | 0.620                         | 79.34        | 1.44                          | 1028.02                  | 415   | 300         |            | 35                | 160        | 40               | 4.00                           | 101.12                        |  |
| 16                 | 51         | 910                 | 0.620                         | 79.34        | 1.44                          | 1031.13                  | 415   | 300         |            | 35                | 160        | 40               | 4.00                           | 101.12                        |  |
| 17                 | 54         | 910                 | 0.620                         | 74.67        | 1.44                          | 1033.10                  | 415   | 290         |            | 35                | 160        | 40               | 3.50                           | 92.18                         |  |
| 18                 | 60         | 910                 | 0.600                         | 73.45        | 1.40                          | 1035.20                  | 415   | 290         |            | 35                | 160        | 40               | 3.50                           | 92.14                         |  |

Table 111.70: Field Sampling Data for Test #3  
Esso-Quirk Creek, November 25, 1983  
Traverse #1

| STACK NO.                | 1             | TEST NO.               | 3                   | TRAVERSE NO.  | 2                   | DELTA P<br>(IN H2O)           | VEL<br>(FT/S) | DELTA H<br>(IN H2O) | GAS METER<br>VOLUME<br>(CUFT) | PROBE               | TEMP<br>OVEN             | A T U R E<br>OUTLET INLET            | S (JEG-F)<br>GAS IN | PUMP<br>- VAC<br>(IN HG) | ISOKINETIC<br>VARIATION<br>(PERCENT) |
|--------------------------|---------------|------------------------|---------------------|---------------|---------------------|-------------------------------|---------------|---------------------|-------------------------------|---------------------|--------------------------|--------------------------------------|---------------------|--------------------------|--------------------------------------|
| SAMPLE<br>POINT<br>(NO.) | TIME<br>(MIN) | STACK<br>TEMP<br>DEG.F | DELTA P<br>(IN H2O) | VEL<br>(FT/S) | DELTA H<br>(IN H2O) | GAS METER<br>VOLUME<br>(CUFT) | PROBE         | TEMP<br>OVEN        | A T U R E<br>OUTLET INLET     | S (JEG-F)<br>GAS IN | PUMP<br>- VAC<br>(IN HG) | ISOKINETIC<br>VARIATION<br>(PERCENT) |                     |                          |                                      |
| 0                        | 0             | 905                    | 0.000               | 73.32         | 1.42                | 35.20                         | 415           | 290                 | 35                            | 103                 | 40                       | 0.00                                 |                     |                          |                                      |
| 1                        | 3             | 905                    | 0.000               | 73.32         | 1.42                | 39.48                         | 415           | 300                 | 40                            | 120                 | 40                       | 97.44                                |                     |                          |                                      |
| 2                        | 6             | 905                    | 0.000               | 76.31         | 1.54                | 41.09                         | 415           | 300                 | 45                            | 130                 | 40                       | 94.53                                |                     |                          |                                      |
| 3                        | 9             | 910                    | 0.000               | 79.34         | 1.65                | 43.97                         | 415           | 300                 | 45                            | 140                 | 40                       | 98.55                                |                     |                          |                                      |
| 4                        | 12            | 910                    | 0.000               | 79.34         | 1.65                | 46.47                         | 415           | 300                 | 45                            | 140                 | 40                       | 106.25                               |                     |                          |                                      |
| 5                        | 15            | 910                    | 0.000               | 80.40         | 1.70                | 48.77                         | 415           | 300                 | 45                            | 145                 | 40                       | 98.30                                |                     |                          |                                      |
| 6                        | 18            | 910                    | 0.000               | 82.12         | 1.77                | 51.03                         | 415           | 300                 | 45                            | 150                 | 40                       | 95.20                                |                     |                          |                                      |
| 7                        | 21            | 910                    | 0.750               | 82.12         | 1.77                | 53.52                         | 415           | 300                 | 45                            | 155                 | 40                       | 97.08                                |                     |                          |                                      |
| 8                        | 24            | 915                    | 0.750               | 83.16         | 1.82                | 55.07                         | 415           | 300                 | 45                            | 155                 | 40                       | 101.82                               |                     |                          |                                      |
| 9                        | 27            | 915                    | 0.770               | 83.16         | 1.82                | 58.14                         | 415           | 300                 | 50                            | 155                 | 40                       | 93.18                                |                     |                          |                                      |
| 10                       | 30            | 915                    | 0.750               | 82.42         | 1.78                | 62.54                         | 415           | 300                 | 50                            | 155                 | 40                       | 99.38                                |                     |                          |                                      |
| 11                       | 33            | 915                    | 0.750               | 82.42         | 1.78                | 65.75                         | 415           | 300                 | 50                            | 155                 | 40                       | 103.00                               |                     |                          |                                      |
| 12                       | 36            | 920                    | 0.670               | 77.76         | 1.59                | 71.45                         | 415           | 290                 | 50                            | 155                 | 40                       | 95.58                                |                     |                          |                                      |
| 13                       | 39            | 915                    | 0.670               | 77.76         | 1.59                | 73.80                         | 415           | 270                 | 50                            | 155                 | 40                       | 105.09                               |                     |                          |                                      |
| 14                       | 42            | 915                    | 0.650               | 76.67         | 1.48                | 76.90                         | 415           | 270                 | 50                            | 155                 | 40                       | 103.03                               |                     |                          |                                      |
| 15                       | 45            | 910                    | 0.570               | 76.67         | 1.48                | 79.13                         | 415           | 260                 | 50                            | 155                 | 40                       | 103.55                               |                     |                          |                                      |
| 16                       | 48            | 910                    | 0.570               | 71.59         | 1.36                | 81.12                         | 415           | 260                 | 50                            | 135                 | 40                       | 104.63                               |                     |                          |                                      |
| 17                       | 51            | 910                    | 0.570               | 71.59         | 1.36                | 81.12                         | 415           | 260                 | 50                            | 130                 | 40                       | 92.88                                |                     |                          |                                      |
| 18                       | 54            | 910                    | 0.570               | 71.59         | 1.36                | 81.12                         | 415           | 260                 | 50                            | 130                 | 40                       | 92.88                                |                     |                          |                                      |
| 19                       | 57            | 910                    | 0.570               | 71.59         | 1.36                | 81.12                         | 415           | 260                 | 50                            | 130                 | 40                       | 92.88                                |                     |                          |                                      |
| 10                       | 60            | 910                    | 0.570               | 71.59         | 1.36                | 81.12                         | 415           | 260                 | 50                            | 130                 | 40                       | 92.88                                |                     |                          |                                      |

Table 111.71: Field Sampling Data for Test #3  
Esso-Quirk Creek, November 25, 1983  
Traverse #2

| Sample Analyses         | Test No. 3 |       | Date  |      | November 25, 1963 |  | Quirk Creek               |                                                 |                                  |
|-------------------------|------------|-------|-------|------|-------------------|--|---------------------------|-------------------------------------------------|----------------------------------|
|                         | Micrograms |       | DP.   |      | Filter            |  | Total Elemental Weight mg | Maximum Possible Elemental Concentration mg/ccf | Elemental Disposition Rate gm/hr |
| Sample From             | DP. 1,2,3, | 4     | DP. 5 |      |                   |  |                           |                                                 |                                  |
| Volume (ml)             | 380.       | 1120. | 240.  | 240. |                   |  | $E_g = 9.0 \times 10^2$   | kg/d (total)                                    |                                  |
| Total Particulates (mg) | 56.91      | 1411. | —     | —    | 18.65             |  | $E_g = 4.6 \times 10^3$   | kg/d (front end)                                |                                  |
| Cr Chromium             | 38.        | 20.   | 24.   | 24.  | 20.               |  | 130.                      | 1.6                                             | 3.3                              |
| Fe Iron                 | 57.        | 50.   | 24.   | 12.  | 10.               |  | 160.                      | 1.9                                             | 3.9                              |
| Mn Manganese            | 95.        | 51.   | 110.  | 60.  | 50.               |  | 370.                      | 4.4                                             | 9.3                              |
| Zn Zinc                 | 76.        | 18.0  | 34.   | 9.6  | 2.0               |  | 160.                      | 1.9                                             | 4.1                              |

All elements except those in boxes ☐ are below the limit of detection.

Table 111.72: Summary of Incinerator Stack Source Sampling  
Data for Elements Whose Presence was Detected  
at the Esso-Quirk Creek Plant, Test #3

APPENDIX IV

PLANT OPERATING DATA

Table IV.1: Operating Data for Canadian Superior Oil Ltd. Harmattan Gas Plant

| Variable                                              | Test                     |                 |                 |                 |
|-------------------------------------------------------|--------------------------|-----------------|-----------------|-----------------|
|                                                       | Preliminary<br>1983 6/23 | #1<br>1983 6/24 | #2<br>1983 6/25 | #3<br>1983 6/26 |
| Plant Inlet<br>MCF/d                                  | 8.91                     | 8.90            | 8.97            | 8.98            |
| Stage VII Inlet<br>MCF/d                              | 88.8                     | 86.5            | 86.8            | 166             |
| Stage VII H <sub>2</sub> S<br>to Stack<br>MCF/d       | 6.41                     | 6.45            | 6.60            | 10.7            |
| Total H <sub>2</sub> S Flow<br>Sulphur Plant<br>MCF/d | 6.99                     | 6.89            | 7.03            | 6.99            |
| Stage VII<br>Fuel Gas<br>MCF/d                        | 3.22                     | 2.60            | 2.14            | 3.12            |
| Sales Gas<br>MCF/d                                    | 3.69                     | 3.61            | 3.75            | 3.77            |
| Stage VII to<br>D-3 Sales<br>MCF/d                    | 4.34                     | shut<br>in      | shut<br>in      | shut<br>in      |
| Stack Temp °F                                         |                          |                 |                 |                 |
| Bottom                                                | 1162                     | 1166            | 1128            | 1148            |
| Middle                                                | 1138                     | 1120            | 1088            | 1108            |
| Top                                                   | 1060                     | 1040            | 1015            | 1033            |
| Stack Volumetric Flow<br>MMSCF/d                      | 37.2                     | 39.4            | 39.5            | 43.0            |

Table IV.2: Operating Data for Petro Canada-Gold Creek Gas Plant

| Variable                                                     | Preliminary<br>1983 7/2 | #1<br>1983 7/3 | Test<br>#2<br>1983 7/4 | #3<br>1983 7/5  |
|--------------------------------------------------------------|-------------------------|----------------|------------------------|-----------------|
| E.G.C. Inlet<br>$10^3 \text{ m}^3/\text{d}$                  | 137                     | 135            | 130                    | 132             |
| Recycle to<br>Sour Sep.<br>$10^3 \text{ m}^3/\text{d}$       | 20.9                    | 19.6           | 19.5                   | 19.9            |
| Flash Gas to<br>Incinerator<br>$10^3 \text{ m}^3/\text{d}$   | 1.13                    | 0.89           | 0.81                   | 0.79            |
| Acid Gas to<br>Sulfur Train<br>$10^3 \text{ m}^3/\text{d}$   | 17.1                    | 16.7           | 16.3                   | 16.6            |
| Treated E.G.C.<br>Gas<br>$10^3 \text{ m}^3/\text{d}$         | 123                     | 122            | 117                    | 119             |
| Fuel to<br>Sulfur Plant<br>$10^3 \text{ m}^3/\text{d}$       | 4.09                    | 5.11           | 5.28                   | 4.94            |
| E.G.C. Cond.<br>Inlet (Field)<br>$10^3 \text{ m}^3/\text{d}$ | 108                     | 111            | 107                    | not<br>recorded |
| Air to Sulfur<br>Train<br>$10^3 \text{ m}^3/\text{d}$        | 36.8                    | 36.0           | 35.4                   | 35.1            |
| Top Stack<br>Temperature<br>°F                               | 914                     | 973            | 966                    | 924             |

Table IV.3: Operating Data for Canterra Energy Limited Rainbow Lake Gas Plant

| Variable                                                             | Test                    |                 |                 |                 |
|----------------------------------------------------------------------|-------------------------|-----------------|-----------------|-----------------|
|                                                                      | Preliminary<br>1983 7/7 | #1<br>1983 7/8  | #2<br>1983 7/9  | #3<br>1983 7/10 |
| Inlet Gas<br>to Absorber<br>$10^3 \text{ m}^3/\text{d}$              | 1840                    | 1824            | 1844            | 1870            |
| Acid Gas<br>to #2 Reaction<br>Furnace<br>$10^3 \text{ m}^3/\text{d}$ | 40.9                    | 39.7            | 40.9            | 39.3            |
| Air to #2<br>Reaction Furnace<br>$10^3 \text{ m}^3/\text{d}$         | not<br>recorded         | not<br>recorded | not<br>recorded | not<br>recorded |
| Acid Gas to<br>#3 Reaction<br>Furnace<br>$10^3 \text{ m}^3/\text{d}$ | 41.4                    | 47.6            | 40.7            | 41.3            |
| Air to #3<br>Reaction Furnace<br>$10^3 \text{ m}^3/\text{d}$         | not<br>recorded         | not<br>recorded | not<br>recorded | not<br>recorded |
| Fuel Gas to<br>Incinerator<br>$10^3 \text{ m}^3/\text{d}$            | 13.5                    | 13.1            | 12.7            | 12.5            |
| H <sub>2</sub> S in<br>Inlet Gas (%)                                 | 3.12                    | 3.16            | 3.04            | 3.04            |
| SO <sub>2</sub> Up Stack<br>(%)                                      | 0.66                    | 0.63            | 0.64            | 0.62            |
| Top Stack<br>Temperature<br>°F                                       | 1170                    | 1174            | 1157            | 1159            |



Table IV.4: Operating Data for Esso Resources Canada Ltd. Quirk Creek Gas Plant

| Variable                                             | Test                      |                  |                  |                  |
|------------------------------------------------------|---------------------------|------------------|------------------|------------------|
|                                                      | Preliminary<br>1983 11/22 | #1<br>1983 11/23 | #2<br>1983 11/24 | #3<br>1983 11/25 |
| Inlet Gas<br>$10^3 \text{ m}^3/\text{d}$             | 1627                      | 1622             | 1655             | 1647             |
| Inlet Cond.<br>$10^5 \text{ gal/m}$                  | 6.41                      | 6.47             | 6.58             | 6.73             |
| Stabilizer Overhead<br>$10^3 \text{ m}^3/\text{d}$   | 55.8                      | 59.4             | 64.6             | 48.9             |
| Inlet to Sulfur Plant<br>$10^3 \text{ m}^3/\text{d}$ | 231                       | 235              | 232              | 238              |
| Fuel Gas<br>$10^3 \text{ m}^3/\text{d}$              | 24.8                      | 23.8             | 24.1             | 24.5             |
| Sales Gas<br>$10^3 \text{ m}^3/\text{d}$             | 1027                      | 1033             | 1032             | 1071             |
| Sales Cond.<br>$10^5 \text{ gal/m}$                  | 5.11                      | 5.15             | 5.21             | 5.28             |

APPENDIX V

PROCEDURES FOR ESTIMATING  
MAXIMUM POSSIBLE EMISSION RATES  
OF ALL ELEMENTS OF INTEREST

## APPENDIX V

Tables V.1 to V.3 summarize the maximum possible emission rates of each of the elements for 3 independent source sampling tests carried out with borosilicate glass lined probes at the Canadian Superior-Harmattan Gas Plant.

Maximum possible elemental emission rates determined from 3 independent source sampling tests with a borosilicate glass lined probe at the Gulf-Nevis Gas Plant are listed in Tables V.4 to V.6.

Three independent source sampling tests with a borosilicate glass lined probe at the Petro Canada-Gold Creek facility generated the data provided by Tables V.7 to V.9.

Tables V.10 to V.12 document the results of sample collection at the Canterra-Rainbow Lake incinerator stack with a borosilicate glass lined probe.

The maximum possible emission rate data for the Esso-Quirk Creek incinerator stack are provided in Tables V.13 to V.15.

Figures V.1 to V.5 illustrate the maximum mean emission rates and the corresponding ranges for the 29 elements of interest at the 5 sour gas plants.

For elements whose presence could not be detected in any part (probe, filter, impingers, cold trap) of the sampling train because their ultimate liquid concentrations for analysis were below the instrumental limits of detection, individual test and mean maximum possible emission rates were estimated by assuming

Table V.1: Summary of Incinerator Stack Source Sampling Tests. Canadian Superior-Harmattan Plant; Test #1.

| Sample Analyses        | Test No | 1           | Date     | June 24, 1983 | Harmattan Maximum Possible                          |                                                  |                                              |
|------------------------|---------|-------------|----------|---------------|-----------------------------------------------------|--------------------------------------------------|----------------------------------------------|
| Sample From            | P4H     | Micrograms  |          | Filter        | Total Elemental Weight $\mu\text{g}$                | Elemental Concentration $\mu\text{g}/\text{ccf}$ | Elemental Emission Rate $\text{g}/\text{hr}$ |
|                        |         | IMP. 1,2,3. | IMP. 4,5 |               |                                                     |                                                  |                                              |
| Volume (ml)            | 550.    | 1270.       | 410.     |               | $E_R = 6.4 \times 10^{-4} \text{ kg/d (total)}$     |                                                  |                                              |
| Total Particulate (mg) | 46.39   | 88063.      | —        | 14.34         | $E_R = 4.5 \times 10^{-1} \text{ kg/d (front end)}$ |                                                  |                                              |
| Ag Silver              | 5.5     | 6.4         | 4.1      | 5.0           | 21.0                                                | 0.34                                             | 0.64                                         |
| Al Aluminum            | 170.    | 110.        | 120.     | 50.0          | 450.                                                | 7.2                                              | 14.                                          |
| As Arsenic             | 0.55    | 6.4         | 4.1      | 0.5           | 12.0                                                | 0.03                                             | 0.06                                         |
| B Boron                | 550.    | 640.        | 410.     | 1000          | 2600                                                | 42.                                              | 80.                                          |
| Be Beryllium           | 2.8     | 2.6         | 3.3      | 1.0           | 9.6                                                 | 0.15                                             | 0.29                                         |
| Cd Cadmium             | 2.8     | 2.5         | 2.5      | 2.0           | 9.8                                                 | 0.16                                             | 0.30                                         |
| Co Cobalt              | 28.0    | 25.0        | 25.0     | 10.0          | 88.0                                                | 1.4                                              | 2.7                                          |
| Cr Chromium            | 28.0    | 75.0        | 25.0     | 20.0          | 150                                                 | 2.4                                              | 4.6                                          |
| Cu Copper              | 28.0    | 25.0        | 25.0     | 10.0          | 98.0                                                | 1.4                                              | 2.7                                          |
| Fe Iron                | 110.    | 710.        | 1500     | 30.0          | 2400                                                | 39.                                              | 74.                                          |
| Ga Gallium             | 280.    | 250.        | 250.     | 200.          | 980.                                                | 16.                                              | 30.                                          |
| Ge Germanium           | 280.    | 250.        | 250.     | 500.          | 1300.                                               | 21.                                              | 40.                                          |
| Hg Mercury             | 4.4     | 3.8         | 3.7      | 10.0          | 22.0                                                | 0.35                                             | 0.67                                         |
| In Indium              | 170.    | 110.        | 120.     | 100.          | 500.                                                | 8.0                                              | 15.                                          |
| Li Lithium             | 5.5     | 6.4         | 4.1      | 3.0           | 19.0                                                | 0.3                                              | 0.58                                         |
| Mn Manganese           | 5.5     | 25.0        | 4.1      | 5.0           | 40.0                                                | 0.64                                             | 1.2                                          |
| Mo Molybdenum          | 55.0    | 64.0        | 41.0     | 20.0          | 180.                                                | 2.9                                              | 5.5                                          |
| Ni Nickel              | 28.0    | 64.0        | 25.0     | 20.0          | 140.                                                | 2.3                                              | 4.3                                          |
| Pb Lead                | 28.0    | 25.0        | 25.0     | 20.0          | 98.0                                                | 1.6                                              | 3.0                                          |
| Sb Antimony            | 55.0    | 51.0        | 41.0     | 20.0          | 170.                                                | 2.7                                              | 5.2                                          |
| Sc Scandium            | 55.0    | 64.0        | 41.0     | 50.0          | 210.                                                | 3.4                                              | 6.4                                          |
| Se Selenium            | 1.7     | 11.0        | 12.0     | 20.0          | 45.0                                                | 0.39                                             | 0.74                                         |
| Sn Tin                 | 170.    | 110.        | 120.     | 50.0          | 450.                                                | 7.23                                             | 14.                                          |
| Sr Strontium           | 5.5     | 6.4         | 4.1      | 5.0           | 21.0                                                | 0.34                                             | 0.64                                         |
| Te Tellurium           | 55.0    | 64.0        | 41.0     | 50.0          | 210.0                                               | 3.4                                              | 6.4                                          |
| Ti Titanium            | 170.    | 110.        | 120.     | 50.0          | 450.                                                | 7.2                                              | 14.                                          |
| Tl Thallium            | 55.0    | 64.0        | 41.0     | 20.0          | 180.                                                | 2.9                                              | 5.5                                          |
| V Vanadium             | 5.5     | 64.0        | 41.0     | 4.0           | 110.                                                | 0.32                                             | 0.61                                         |
| Zn Zinc                | 52.0    | 81.0        | 74.0     | 3.0           | 170.                                                | 2.7                                              | 5.2                                          |

All elements except those in boxes ☐ are below the limit of detection.

Table V.2: Summary of Incinerator Stack Source Sampling Tests. Canadian Superior-Harmattan Plant; Test #2

| Sample Analyses        |       | Test No     | 2        | Date   | June 25, 1983                                    | Harmattan Maximum Possible                       |                                               |
|------------------------|-------|-------------|----------|--------|--------------------------------------------------|--------------------------------------------------|-----------------------------------------------|
| Sample From            | P&H   | Micrograms  |          | Filter | Total Elemental Weight $\mu\text{g}$             | Elemental Concentration $\mu\text{g}/\text{ccf}$ | Elemental Emission Rate $\text{gm}/\text{hr}$ |
|                        |       | IMP. 1,2,3. | IMP. 4,5 |        |                                                  |                                                  |                                               |
| Volume (ml)            | 470.  | 1275.       | 335.     |        | $E_R = 4.3 \times 10^4 \text{ kg/d (total)}$     |                                                  |                                               |
| Total Particulate (mg) | 106.2 | 50358.      | —        | 6.894  | $E_R = 9.8 \times 10^1 \text{ kg/d (front end)}$ |                                                  |                                               |
| Ag Silver              | 9.4   | 6.4         | 6.7      | 5.0    | 27.0                                             | 0.49                                             | 0.97                                          |
| Al Aluminum            | 140.  | 110.        | 100.     | 50.0   | 410.                                             | 7.5                                              | 15.                                           |
| As Arsenic             | 4.2   | 6.4         | 0.67     | 0.5    | 12.0                                             | 0.11                                             | 0.22                                          |
| B Boron                | 940.  | 640.        | 670.     | 1000   | 3200                                             | 58.                                              | 120.                                          |
| Be Beryllium           | 3.3   | 2.6         | 2.3      | 1.0    | 9.2                                              | 0.17                                             | 0.33                                          |
| Cd Cadmium             | 3.3   | 2.6         | 2.3      | 2.0    | 10.0                                             | 0.18                                             | 0.36                                          |
| Co Cobalt              | 33.0  | 26.0        | 23.0     | 10.0   | 92.0                                             | 1.7                                              | 3.3                                           |
| Cr Chromium            | 33.0  | 26.0        | 23.0     | 20.0   | 100.                                             | 1.8                                              | 3.6                                           |
| Cu Copper              | 310.  | 26.0        | 23.0     | 10.0   | 370.                                             | 6.8                                              | 13.                                           |
| Fe Iron                | 47000 | 360.        | 2700     | 10.0   | 50000                                            | 910.                                             | 1800.                                         |
| Ga Gallium             | 330.  | 260.        | 230.     | 200.   | 1000                                             | 18.                                              | 36.                                           |
| Ge Germanium           | 330.  | 260.        | 230.     | 500.   | 1300                                             | 24.                                              | 47.                                           |
| Hg Mercury             | 4.7   | 3.8         | 3.4      | 10.0   | 22.0                                             | 0.40                                             | 0.79                                          |
| In Indium              | 140.  | 110.        | 100.     | 100.   | 460.                                             | 8.4                                              | 17.                                           |
| Li Lithium             | 9.4   | 6.4         | 6.7      | 3.0    | 25.0                                             | 0.46                                             | 0.90                                          |
| Mn Manganese           | 190.  | 6.4         | 10.0     | 5.0    | 210.                                             | 3.8                                              | 7.5                                           |
| Mo Molybdenum          | 94.0  | 64.0        | 67.0     | 20.0   | 240.                                             | 4.4                                              | 8.6                                           |
| Ni Nickel              | 47.0  | 26.0        | 23.0     | 20.0   | 120.                                             | 2.2                                              | 4.3                                           |
| Pb Lead                | 33.0  | 26.0        | 23.0     | 20.0   | 100.                                             | 1.8                                              | 3.6                                           |
| Sb Antimony            | 47.0  | 51.0        | 34.0     | 20.0   | 150.                                             | 2.7                                              | 5.4                                           |
| Sc Scandium            | 94.0  | 64.0        | 67.0     | 50.0   | 270.                                             | 4.9                                              | 9.7                                           |
| Se Selenium            | 1.4   | 11.0        | 1.0      | 20.0   | 34.0                                             | 0.43                                             | 0.84                                          |
| Sn Tin                 | 140.  | 110.        | 100.     | 50.0   | 410.                                             | 7.5                                              | 15.                                           |
| Sr Strontium           | 9.4   | 6.4         | 6.7      | 5.0    | 27.0                                             | 0.49                                             | 0.97                                          |
| Te Tellurium           | 94.0  | 64.0        | 67.0     | 50.0   | 270.                                             | 4.9                                              | 9.7                                           |
| Ti Titanium            | 140.  | 110.        | 100.     | 50.0   | 410.                                             | 7.5                                              | 15.                                           |
| Tl Thallium            | 94.0  | 64.0        | 67.0     | 20.0   | 240.                                             | 4.4                                              | 8.6                                           |
| V Vanadium             | 9.4   | 64.0        | 6.7      | 4.0    | 84.0                                             | 0.48                                             | 0.95                                          |
| Zn Zinc                | 12000 | 23.0        | 70.0     | 2.0    | 12000                                            | 220.                                             | 430.                                          |

All elements except those in boxes are below the limit of detection.

Table V.3: Summary of Incinerator Stack Source Sampling Tests. Canadian Superior-Harmattan Plant; Test #3

| Analysis               |       | Test No     | 3        | Date   | June 26, 1983                                    | Harmattan                                        |                                               |
|------------------------|-------|-------------|----------|--------|--------------------------------------------------|--------------------------------------------------|-----------------------------------------------|
|                        |       | Micrograms  |          |        |                                                  | Maximum Possible                                 |                                               |
| Sample From            | P&H   | IMP. 1,2,3, | IMP. 4,5 | Filter | Total Elemental Weight $\mu\text{g}$             | Elemental Concentration $\mu\text{g}/\text{scf}$ | Elemental Emission Rate $\text{gm}/\text{hr}$ |
| Volume (ml)            | 570.  | 1230        | 425.     |        | $E_R = 3.9 \times 10^4 \text{ kg/d (total)}$     |                                                  |                                               |
| Total Particulate (mg) | 14.91 | 44550.      | —        | 9.552  | $E_R = 2.1 \times 10^1 \text{ kg/d (front end)}$ |                                                  |                                               |
| Ag Silver              | 5.7   | 6.2         | 4.3      | 5.0    | 21.0                                             | 0.38                                             | 0.76                                          |
| Al Aluminum            | 170.  | 120.        | 128.     | 50.0   | 470.                                             | 8.5                                              | 17.                                           |
| As Arsenic             | 0.57  | 6.2         | 2.1      | 0.5    | 9.3                                              | 0.04                                             | 0.08                                          |
| B Boron                | 570.  | 62.0        | 43.0     | 1000   | 2600                                             | 47.                                              | 95.                                           |
| Be Beryllium           | 2.9   | 2.5         | 2.1      | 1.0    | 8.4                                              | 0.15                                             | 0.31                                          |
| Cd Cadmium             | 2.9   | 2.5         | 2.1      | 2.0    | 9.4                                              | 0.17                                             | 0.34                                          |
| Co Cobalt              | 29.0  | 25.0        | 21.0     | 10.0   | 84.0                                             | 1.5                                              | 3.1                                           |
| Cr Chromium            | 29.0  | 25.0        | 21.0     | 20.0   | 94.0                                             | 1.7                                              | 3.4                                           |
| Cu Copper              | 29.0  | 25.0        | 21.0     | 10.0   | 84.0                                             | 1.5                                              | 3.1                                           |
| Fe Iron                | 540.  | 200.        | 340.     | 40.0   | 1100                                             | 20.                                              | 40.                                           |
| Ga Gallium             | 290.  | 250.        | 210.     | 200.   | 940.                                             | 17.                                              | 34.                                           |
| Ge Germanium           | 290.  | 250.        | 210.     | 500.   | 1200                                             | 22.                                              | 44.                                           |
| Hg Mercury             | 4.6   | 3.7         | 3.4      | 10.0   | 22.0                                             | 0.40                                             | 0.80                                          |
| In Indium              | 170.  | 120.        | 130.     | 100.   | 520.                                             | 9.4                                              | 19.                                           |
| Li Lithium             | 5.7   | 6.2         | 4.3      | 3.0    | 19.0                                             | 0.35                                             | 0.69                                          |
| Mn Manganese           | 5.7   | 6.2         | 4.3      | 5.0    | 21.0                                             | 0.38                                             | 0.76                                          |
| Mo Molybdenum          | 57.0  | 62.0        | 43.0     | 20.0   | 180.                                             | 3.3                                              | 6.6                                           |
| Ni Nickel              | 29.0  | 25.0        | 43.0     | 20.0   | 120.                                             | 2.2                                              | 4.4                                           |
| Pb Lead                | 29.0  | 25.0        | 21.0     | 20.0   | 94.0                                             | 1.7                                              | 3.4                                           |
| Sb Antimony            | 57.0  | 49.0        | 43.0     | 20.0   | 170.                                             | 3.1                                              | 6.2                                           |
| Sc Scandium            | 57.0  | 62.0        | 43.0     | 50.0   | 210.                                             | 3.8                                              | 7.6                                           |
| Se Selenium            | 1.7   | 12.0        | 1.3      | 20.0   | 35.0                                             | 0.44                                             | 0.88                                          |
| Sn Tin                 | 170.  | 120.        | 130.     | 50.0   | 470.                                             | 8.5                                              | 17.                                           |
| Sr Strontium           | 5.7   | 6.2         | 4.3      | 5.0    | 21.0                                             | 0.38                                             | 0.76                                          |
| Te Tellurium           | 57.0  | 62.0        | 43.0     | 50.0   | 210.                                             | 3.8                                              | 7.6                                           |
| Ti Titanium            | 170.  | 120.        | 130.     | 50.0   | 470.                                             | 8.5                                              | 17.                                           |
| Tl Thallium            | 57.0  | 62.0        | 43.0     | 20.0   | 180.                                             | 3.3                                              | 6.6                                           |
| V Vanadium             | 5.7   | 62.0        | 4.3      | 4.0    | 75.0                                             | 0.37                                             | 0.74                                          |
| Zn Zinc                | 63.0  | 42.0        | 38.0     | 3.0    | 150.                                             | 2.7                                              | 5.5                                           |

All elements except those in boxes ☐ are below the limit of detection.

Table V.4: Summary of Incinerator Stack Source Sampling Tests. Gulf-Nevis Plant; Test #1

| Sample Analyses        | Test No | 1          | Date        | June 28, 1983 | Nevis  |                                                     |                     |
|------------------------|---------|------------|-------------|---------------|--------|-----------------------------------------------------|---------------------|
|                        |         |            |             |               |        | Maximum Possible                                    |                     |
|                        |         |            |             |               |        | Elemental                                           | Elemental           |
|                        |         |            |             |               |        | Concentration                                       | Emission            |
| Sample From            | P&H     | Micrograms | IMP. 1,2,3, | IMP. 4,5      | Filter | Total Elemental Weight $\mu\text{g}$                | Rate $\text{gm/hr}$ |
| Volume (ml)            | 470.    | 1100       | 470.        |               |        | $E_R = 1.4 \times 10^{-4} \text{ kg/d (total)}$     |                     |
| Total Particulate (mg) | 45.44   | 56994.     | —           | 21.88         |        | $E_R = 1.6 \times 10^{-1} \text{ kg/d (front end)}$ |                     |
| Ag Silver              | 9.4     | 5.5        | 4.7         | 5.0           | 25.0   | 0.31                                                | 0.25                |
| Al Aluminum            | 140.    | 110.       | 4200        | 50.0          | 4500   | 55.                                                 | 45.                 |
| As Arsenic             | 0.094   | 0.55       | 4.0         | 0.5           | 6.0    | 0.07                                                | 0.06                |
| B Boron                | 940.    | 550.       | 470.        | 1000          | 3000   | 37.                                                 | 30.                 |
| Be Beryllium           | 3.3     | 2.2        | 2.4         | 1.0           | 8.8    | 0.11                                                | 0.09                |
| Cd Cadmium             | 3.3     | 2.2        | 2.4         | 2.0           | 9.8    | 0.12                                                | 0.10                |
| Co Cobalt              | 33.0    | 22.0       | 24.0        | 10.0          | 88.0   | 1.1                                                 | 0.88                |
| Cr Chromium            | 33.0    | 22.0       | 24.0        | 20.0          | 98.0   | 1.2                                                 | 0.98                |
| Cu Copper              | 33.0    | 22.0       | 23.5        | 10.0          | 88.4   | 1.1                                                 | 0.88                |
| Fe Iron                | 280.    | 660.       | 710.        | 10.0          | 1700   | 21.                                                 | 17.                 |
| Ga Gallium             | 330.    | 220.       | 240.        | 200.          | 980.   | 12.                                                 | 9.8                 |
| Ge Germanium           | 330.    | 220.       | 240.        | 500.          | 1300   | 16.                                                 | 13.                 |
| Hg Mercury             | 4.7     | 3.3        | 3.8         | 10.0          | 22.0   | 0.27                                                | 0.22                |
| In Indium              | 140.    | 110.       | 140.        | 100.          | 490.   | 6.0                                                 | 4.9                 |
| Li Lithium             | 9.4     | 5.5        | 4.7         | 3.0           | 23.0   | 0.28                                                | 0.23                |
| Mn Manganese           | 9.4     | 5.5        | 4.7         | 5.0           | 25.0   | 0.31                                                | 0.25                |
| Mo Molybdenum          | 94.0    | 55.0       | 47.0        | 20.0          | 220.   | 2.7                                                 | 2.2                 |
| Ni Nickel              | 33.0    | 22.0       | 24.0        | 20.0          | 98.0   | 1.2                                                 | 0.98                |
| Pb Lead                | 33.0    | 22.0       | 24.0        | 20.0          | 98.0   | 1.2                                                 | 0.98                |
| Sb Antimony            | 47.0    | 44.0       | 47.0        | 20.0          | 160.   | 2.0                                                 | 1.6                 |
| Sc Scandium            | 94.0    | 55.0       | 47.0        | 50.0          | 250.   | 3.1                                                 | 2.5                 |
| Se Selenium            | 1.4     | 1.1        | 1.4         | 20.0          | 24.0   | 0.30                                                | 0.24                |
| Sn Tin                 | 140.    | 110.       | 140.        | 50.0          | 440.   | 5.4                                                 | 4.4                 |
| Sr Strontium           | 9.4     | 5.5        | 4.7         | 5.0           | 25.0   | 0.3                                                 | 0.25                |
| Te Tellurium           | 94.0    | 55.0       | 47.0        | 50.0          | 25.0   | 3.1                                                 | 2.5                 |
| Ti Titanium            | 140.    | 110.       | 140.        | 50.0          | 440.   | 5.4                                                 | 4.4                 |
| Tl Thallium            | 94.0    | 55.0       | 47.0        | 20.0          | 220.   | 2.7                                                 | 2.2                 |
| V Vanadium             | 9.4     | 5.5        | 4.7         | 4.0           | 24.0   | 0.30                                                | 0.24                |
| Zn Zinc                | 61.0    | 63.0       | 89.0        | 3.0           | 220.   | 2.7                                                 | 2.2                 |

All elements except those in boxes ☐ are below the limit of detection.



Table V.5: Summary of Incinerator Stack Source  
Sampling Tests. Gulf-Nevis  
Plant; Test #2

| Sample<br>Analyses        | Test No 2 | Date June 29, 1983           | Nevis<br>Maximum Possible |        |                                          |                                           |                                        |
|---------------------------|-----------|------------------------------|---------------------------|--------|------------------------------------------|-------------------------------------------|----------------------------------------|
| Sample<br>From            | PLN       | Micrograms<br>IMP.<br>1,2,3, | IMP.<br>4,5               | Filter | Total<br>Elemental<br>Weight<br>pg       | Elemental<br>Concen-<br>tration<br>µg/scf | Elemental<br>Emission<br>Rate<br>gm/hr |
| Volume (ml)               | 330.      | 1150                         | 265                       |        |                                          |                                           |                                        |
| Total Particulate<br>(mg) | 43.61     | 36624.                       | —                         | 21.85  | $E_A = 6.4 \times 10^3$ kg/d (total)     |                                           |                                        |
|                           |           |                              |                           |        | $E_A = 1.1 \times 10^1$ kg/d (front end) |                                           |                                        |
| Ag Silver                 | 9.9       | 5.8                          | 8.0                       | 5.0    | 29.0                                     | 0.28                                      | 0.21                                   |
| Al Aluminum               | 330.      | 120.                         | 130.                      | 50.0   | 630.                                     | 6.1                                       | 4.6                                    |
| As Arsenic                | 0.99      | 5.8                          | 0.8                       | 0.5    | 8.0                                      | 0.03                                      | 0.02                                   |
| B Boron                   | 990.      | 580.                         | 800.                      | 1000   | 1400                                     | 33.                                       | 25.                                    |
| Be Beryllium              | 3.3       | 2.3                          | 2.7                       | 1.0    | 9.3                                      | 0.09                                      | 0.07                                   |
| Cd Cadmium                | 3.3       | 2.3                          | 2.7                       | 2.0    | 10.0                                     | 0.10                                      | 0.07                                   |
| Co Cobalt                 | 33.0      | 23.0                         | 27.0                      | 10.0   | 93.0                                     | 0.90                                      | 0.68                                   |
| Cr Chromium               | 33.0      | 23.0                         | 27.0                      | 20.0   | 100.                                     | 0.96                                      | 0.73                                   |
| Cu Copper                 | 33.0      | 23.0                         | 27.0                      | 10.0   | 93.0                                     | 0.90                                      | 0.68                                   |
| Fe Iron                   | 200.      | 170.                         | 240.                      | 20.0   | 630.                                     | 6.1                                       | 4.6                                    |
| Ga Gallium                | 330.      | 230.                         | 270.                      | 200.   | 1000                                     | 9.6                                       | 7.3                                    |
| Ge Germanium              | 330.      | 230.                         | 270.                      | 500.   | 1300                                     | 13.                                       | 9.5                                    |
| Hg Mercury                | 6.6       | 3.5                          | 5.3                       | 10.0   | 25.0                                     | 0.24                                      | 0.18                                   |
| In Indium                 | 170.      | 120.                         | 130.                      | 100.   | 510.                                     | 4.9                                       | 3.7                                    |
| Li Lithium                | 9.9       | 5.8                          | 8.0                       | 3.0    | 27.0                                     | 0.26                                      | 0.20                                   |
| Mn Manganese              | 9.9       | 8.1                          | 8.0                       | 5.0    | 31.0                                     | 0.30                                      | 0.23                                   |
| Mo Molybdenum             | 99.0      | 58.0                         | 80.0                      | 20.0   | 260.                                     | 2.5                                       | 1.9                                    |
| Ni Nickel                 | 33.0      | 23.0                         | 27.0                      | 20.0   | 100.                                     | 0.96                                      | 0.73                                   |
| Pb Lead                   | 33.0      | 23.0                         | 27.0                      | 20.0   | 100.                                     | 0.96                                      | 0.73                                   |
| Sb Antimony               | 66.0      | 46.0                         | 53.0                      | 20.0   | 190.                                     | 1.8                                       | 1.4                                    |
| Sc Scandium               | 99.0      | 58.0                         | 80.0                      | 50.0   | 290.                                     | 2.8                                       | 2.1                                    |
| Se Selenium               | 1.7       | 12.0                         | 1.3                       | 20.0   | 34.0                                     | 0.23                                      | 0.18                                   |
| Sn Tin                    | 170.      | 120.                         | 130.                      | 50.0   | 460.                                     | 4.4                                       | 3.4                                    |
| Sr Strontium              | 9.9       | 5.8                          | 8.0                       | 5.0    | 29.0                                     | 0.28                                      | 0.21                                   |
| Te Tellurium              | 99.0      | 58.0                         | 80.0                      | 50.0   | 290.                                     | 2.8                                       | 2.1                                    |
| Ti Titanium               | 170.      | 120.                         | 130.                      | 50.0   | 460.                                     | 4.4                                       | 3.4                                    |
| Tl Thallium               | 99.0      | 58.0                         | 80.0                      | 20.0   | 260.                                     | 2.5                                       | 1.9                                    |
| V Vanadium                | 9.9       | 58.0                         | 8.0                       | 4.0    | 79.0                                     | 0.27                                      | 0.20                                   |
| Zn Zinc                   | 46.0      | 110.                         | 82.0                      | 3.0    | 240.                                     | 2.3                                       | 1.8                                    |

All elements except those in boxes ☐ are below the limit of detection.

Table V.6: Summary of Incinerator Stack Source Sampling Tests. Gulf-Nevis Plant; Test #3

| Sample Analyses        | Test No 3 | Date June 30, 1983     |          | Nevis Maximum Possible Elemental Concentration |                                                  |                                           |                                        |
|------------------------|-----------|------------------------|----------|------------------------------------------------|--------------------------------------------------|-------------------------------------------|----------------------------------------|
| Sample From            | P&N       | Micrograms IMP. 1,2,3, | IMP. 4,5 | Filter                                         | Total Elemental Weight $\mu\text{g}$             | Elemental Concentration $\mu\text{g/ccf}$ | Elemental Emission Rate $\text{gm/hr}$ |
| Volume (ml)            | 390.      | 1350                   | 385.     |                                                | $E_R = 9.5 \times 10^3 \text{ kg/d (total)}$     |                                           |                                        |
| Total Particulate (mg) | 59.77     | 54147.                 | —        | 28.38                                          | $E_R = 1.5 \times 10^1 \text{ kg/d (front end)}$ |                                           |                                        |
| Ag Silver              | 12.0      | 6.8                    | 7.7      | 5.0                                            | 31.0                                             | 0.30                                      | 0.23                                   |
| Al Aluminum            | 160.      | 120.                   | 120.     | 50.0                                           | 440.                                             | 4.3                                       | 3.2                                    |
| As Arsenic             | 0.78      | 6.8                    | 0.77     | 0.5                                            | 8.8                                              | 0.03                                      | 0.02                                   |
| B Boron                | 1200      | 680.                   | 770.     | 1000                                           | 3600                                             | 35.                                       | 26.                                    |
| Be Beryllium           | 3.1       | 2.7                    | 2.7      | 1.0                                            | 9.5                                              | 0.09                                      | 0.07                                   |
| Cd Cadmium             | 3.1       | 2.7                    | 2.7      | 2.0                                            | 10.5                                             | 0.11                                      | 0.08                                   |
| Co Cobalt              | 31.0      | 27.0                   | 27.0     | 10.0                                           | 95.0                                             | 0.93                                      | 0.69                                   |
| Cr Chromium            | 31.0      | 27.0                   | 230.     | 20.0                                           | 310.                                             | 3.0                                       | 2.3                                    |
| Cu Copper              | 31.0      | 27.0                   | 27.0     | 10.0                                           | 95.0                                             | 0.93                                      | 0.69                                   |
| Fe Iron                | 39.0      | 2700                   | 730.     | 20.0                                           | 3500                                             | 34.                                       | 26.                                    |
| Ga Gallium             | 310.      | 270.                   | 270.     | 200.                                           | 1100                                             | 11.                                       | 8.0                                    |
| Ge Germanium           | 310.      | 270.                   | 270.     | 500.                                           | 1400                                             | 14.                                       | 10.                                    |
| Hg Mercury             | 3.9       | 4.1                    | 3.9      | 10.0                                           | 22.0                                             | 0.22                                      | 0.16                                   |
| In Indium              | 160.      | 120.                   | 120.     | 100.                                           | 490.                                             | 4.8                                       | 3.6                                    |
| Li Lithium             | 7.8       | 6.8                    | 7.7      | 3.0                                            | 25.0                                             | 0.24                                      | 0.18                                   |
| Mn Manganese           | 7.8       | 9.5                    | 12.0     | 5.0                                            | 34.0                                             | 0.33                                      | 0.25                                   |
| Mo Molybdenum          | 78.0      | 68.0                   | 77.0     | 20.0                                           | 240.                                             | 2.3                                       | 1.8                                    |
| Ni Nickel              | 31.0      | 27.0                   | 77.0     | 20.0                                           | 160.                                             | 1.6                                       | 1.2                                    |
| Pb Lead                | 31.0      | 27.0                   | 27.0     | 20.0                                           | 110.                                             | 1.1                                       | 0.80                                   |
| Sb Antimony            | 78.0      | 54.0                   | 39.0     | 20.0                                           | 190.                                             | 1.9                                       | 1.4                                    |
| Sc Scandium            | 78.0      | 68.0                   | 77.0     | 50.0                                           | 270.                                             | 2.6                                       | 2.0                                    |
| Se Selenium            | 1.6       | 12.0                   | 1.2      | 20.0                                           | 35.0                                             | 0.24                                      | 0.18                                   |
| Sn Tin                 | 160.      | 120.                   | 120.     | 50.0                                           | 440.                                             | 4.3                                       | 3.2                                    |
| Sr Strontium           | 7.8       | 6.8                    | 7.7      | 5.0                                            | 27.0                                             | 0.26                                      | 0.20                                   |
| Te Tellurium           | 78.0      | 68.0                   | 77.0     | 50.0                                           | 270.                                             | 2.6                                       | 2.0                                    |
| Ti Titanium            | 160.      | 120.                   | 120.     | 50.0                                           | 440.                                             | 4.3                                       | 3.2                                    |
| Tl Thallium            | 78.0      | 68.0                   | 77.0     | 20.0                                           | 240.                                             | 2.3                                       | 1.8                                    |
| V Vanadium             | 7.8       | 68.0                   | 7.7      | 4.0                                            | 87.0                                             | 0.25                                      | 0.19                                   |
| Zn Zinc                | 43.0      | 110.                   | 96.0     | 3.0                                            | 250.                                             | 2.4                                       | 1.8                                    |

All elements except those in boxes are below the limit of detection.

Table V.7: Summary of Incinerator Stack Source  
Sampling Tests. Petro Canada-  
Gold Creek Plant; Test #1

| Sample Analyses        | Test No 1 | Date July 3, 1983 |          |        | Gold Creek Maximum Possible |                                |                               |
|------------------------|-----------|-------------------|----------|--------|-----------------------------|--------------------------------|-------------------------------|
|                        |           | <u>Micrograms</u> |          |        |                             |                                |                               |
| Sample From            | P&H       | IMP. 1,2,3,       | IMP. 4,5 | Filter | Total Elemental Weight pg   | Elemental Concentration µg/rcf | Elemental Emission Rate gm/hr |
| Volume (ml)            | 450.      | 1065.             | 405.     |        | $E_R = 2.4 \times 10^3$     | kg/d (total)                   |                               |
| Total Particulate (mg) | 47.40     | 33098.            | —        | 26.68  | $E_R = 5.4$                 | kg/d (front end)               |                               |
| Ag Silver              | 4.5       | 6.4               | 4.1      | 5.0    | 20.0                        | 0.21                           | 0.06                          |
| Al Aluminum            | 140.      | 110.              | 120.     | 50.0   | 410.                        | 4.3                            | 1.2                           |
| As Arsenic             | 1.4       | 4.3               | 1.2      | 0.5    | 7.3                         | 0.08                           | 0.02                          |
| B Boron                | 1400      | 1100              | 810.     | 1000   | 4200                        | 44.                            | 13.                           |
| Be Beryllium           | 2.7       | 17.0              | 2.0      | 1.0    | 23.0                        | 0.24                           | 0.07                          |
| Cd Cadmium             | 2.7       | 2.1               | 2.0      | 2.0    | 8.9                         | 0.09                           | 0.03                          |
| Co Cobalt              | 27.0      | 21.0              | 20.0     | 10.0   | 79.0                        | 0.83                           | 0.24                          |
| Cr Chromium            | 27.0      | 21.0              | 20.0     | 20.0   | 89.0                        | 0.94                           | 0.27                          |
| Cu Copper              | 14.0      | 11.0              | 12.0     | 10.0   | 46.0                        | 0.48                           | 0.14                          |
| Fe Iron                | 41.0      | 120.              | 20.0     | 30.0   | 210.                        | 2.2                            | 0.63                          |
| Ga Gallium             | 270.      | 210.              | 200.     | 200.   | 890.                        | 9.4                            | 2.7                           |
| Ge Germanium           | 140.      | 110.              | 120.     | 500.   | 860.                        | 9.1                            | 2.6                           |
| Hg Mercury             | 4.5       | 6.4               | 4.1      | 10.0   | 25.0                        | 0.26                           | 0.08                          |
| In Indium              | 140.      | 110.              | 120.     | 100.   | 460.                        | 4.8                            | 1.4                           |
| Li Lithium             | 4.5       | 6.4               | 4.1      | 1.0    | 18.0                        | 0.19                           | 0.05                          |
| Mn Manganese           | 4.5       | 6.4               | 4.1      | 5.0    | 20.0                        | 0.21                           | 0.06                          |
| Mo Molybdenum          | 27.0      | 21.0              | 8.1      | 20.0   | 76.0                        | 0.80                           | 0.23                          |
| Ni Nickel              | 27.0      | 21.0              | 20.0     | 20.0   | 89.0                        | 0.94                           | 0.27                          |
| Pb Lead                | 27.0      | 21.0              | 20.0     | 20.0   | 89.0                        | 0.94                           | 0.27                          |
| Sb Antimony            | 45.0      | 43.0              | 41.0     | 20.0   | 150.                        | 1.6                            | 0.45                          |
| Sc Scandium            | 45.0      | 64.0              | 41.0     | 50.0   | 200.                        | 2.1                            | 0.60                          |
| Se Selenium            | 2.7       | 7.5               | 4.1      | 20.0   | 34.0                        | 0.36                           | 0.10                          |
| Sn Tin                 | 140.      | 110.              | 120.     | 50.0   | 410.                        | 4.3                            | 1.2                           |
| Sr Strontium           | 4.5       | 6.4               | 4.1      | 5.0    | 20.0                        | 0.21                           | 0.06                          |
| Te Tellurium           | 45.0      | 64.0              | 41.0     | 50.0   | 200.                        | 2.1                            | 0.60                          |
| Ti Titanium            | 140.      | 110.              | 120.     | 50.0   | 410.                        | 4.3                            | 1.2                           |
| Tl Thallium            | 45.0      | 64.0              | 41.0     | 20.0   | 170.                        | 1.8                            | 0.51                          |
| V Vanadium             | 45.0      | 64.0              | 41.0     | 4.0    | 150.                        | 1.6                            | 0.45                          |
| Zn Zinc                | 4.1       | 32.0              | 3.2      | 3.0    | 42.0                        | 0.44                           | 0.13                          |

All elements except those in boxes ☐ are below the limit of detection

Table V.8: Summary of Incinerator Stack Source Sampling Tests. Petro Canada-Gold Creek Plant; Test #2

| Sample Analyses        | Test No | 2           | Date     | July 4, 1983 | Gold Creek Maximum Possible          |                         |                         |
|------------------------|---------|-------------|----------|--------------|--------------------------------------|-------------------------|-------------------------|
|                        |         | Micrograms  |          |              | Total Elemental Weight               | Elemental Concentration | Elemental Emission Rate |
| Sample From            | PM      | IMP. 1,2,3, | IMP. 4,5 | Filter       | µg                                   | µg/scf                  | gm/hr                   |
| Volume (ml)            | 445.    | 1005        | 295.     |              | $E_p = 1.4 \times 10^3$ kg/d (total) |                         |                         |
| Total Particulate (mg) | 29.30   | 19316.      | —        | 18.18        | $E_p = 3.5$                          | kg/d (front end)        |                         |
| Ag Silver              | 4.5     | 6.0         | 5.9      | 5.0          | 21.0                                 | 0.22                    | 0.06                    |
| Al Aluminum            | 130.    | 100.        | 120.     | 50.0         | 400.                                 | 4.3                     | 1.2                     |
| As Arsenic             | 1.3     | 1.0         | 1.2      | 0.5          | 4.0                                  | 0.04                    | 0.01                    |
| B Boron                | 1300    | 1000        | 1200     | 1000         | 4500                                 | 48.                     | 14.                     |
| Be Beryllium           | 2.7     | 2.0         | 2.4      | 1.0          | 8.0                                  | 0.09                    | 0.02                    |
| Cd Cadmium             | 2.7     | 2.0         | 2.4      | 2.0          | 9.0                                  | 0.10                    | 0.03                    |
| Co Cobalt              | 27.0    | 20.0        | 24.0     | 10.0         | 80.0                                 | 0.85                    | 0.24                    |
| Cr Chromium            | 27.0    | 20.0        | 24.0     | 20.0         | 90.0                                 | 0.95                    | 0.27                    |
| Cu Copper              | 13.0    | 10.0        | 12.0     | 10.0         | 45.0                                 | 0.48                    | 0.14                    |
| Fe Iron                | 13.0    | 60.0        | 24.0     | 10.0         | 110.                                 | 1.2                     | 0.33                    |
| Ga Gallium             | 270.    | 200.        | 240.     | 200.         | 900.                                 | 9.6                     | 2.7                     |
| Ge Germanium           | 130.    | 100.        | 120.     | 500.         | 850.                                 | 9.1                     | 2.6                     |
| Hg Mercury             | 4.5     | 6.0         | 5.9      | 10.0         | 26.0                                 | 0.28                    | 0.08                    |
| In Indium              | 130.    | 100.        | 120.     | 100.         | 450.                                 | 4.8                     | 1.4                     |
| Li Lithium             | 4.5     | 6.0         | 5.9      | 3.0          | 19.0                                 | 0.20                    | 0.06                    |
| Mn Manganese           | 4.5     | 6.0         | 5.9      | 5.0          | 21.0                                 | 0.22                    | 0.06                    |
| Mo Molybdenum          | 27.0    | 20.0        | 24.0     | 20.0         | 90.0                                 | 0.96                    | 0.27                    |
| Ni Nickel              | 27.0    | 20.0        | 24.0     | 20.0         | 90.0                                 | 0.96                    | 0.27                    |
| Pb Lead                | 27.0    | 20.0        | 24.0     | 20.0         | 90.0                                 | 0.96                    | 0.27                    |
| Sb Antimony            | 45.0    | 40.0        | 59.0     | 20.0         | 160.                                 | 1.7                     | 0.49                    |
| Sc Scandium            | 45.0    | 60.0        | 59.0     | 50.0         | 210.                                 | 2.2                     | 0.64                    |
| Se Selenium            | 2.7     | 7.0         | 2.4      | 20.0         | 32.0                                 | 0.34                    | 0.10                    |
| Sn Tin                 | 130.    | 100.        | 120.     | 50.0         | 400.                                 | 4.3                     | 1.2                     |
| Sr Strontium           | 4.5     | 6.0         | 5.9      | 5.0          | 21.0                                 | 0.22                    | 0.06                    |
| Te Tellurium           | 45.0    | 60.0        | 59.0     | 50.0         | 210.                                 | 2.2                     | 0.64                    |
| Ti Titanium            | 130.    | 100.        | 120.     | 50.0         | 400.                                 | 4.3                     | 1.2                     |
| Tl Thallium            | 45.0    | 60.0        | 59.0     | 20.0         | 180.                                 | 1.9                     | 0.55                    |
| V Vanadium             | 45.0    | 60.0        | 59.0     | 4.0          | 170.                                 | 1.8                     | 0.52                    |
| Zn Zinc                | 4.0     | 33.0        | 21.0     | 3.0          | 61.0                                 | 0.65                    | 0.19                    |

All elements except those in boxes are below limit of detection

Table V.9: Summary of Incinerator Stack Source  
Sampling Tests. Petro Canada-  
Gold Creek Plant; Test #3

| Sample Analyses        | Test No 3 | Date July 5, 1983 |          |        | Gold Creek                                   |                                                  |                                               |
|------------------------|-----------|-------------------|----------|--------|----------------------------------------------|--------------------------------------------------|-----------------------------------------------|
|                        |           | <u>Micrograms</u> |          |        |                                              |                                                  |                                               |
| Sample From            | PEN       | IMP. 1,2,3,       | IMP. 4,5 | Filter | Total Elemental Weight $\mu\text{g}$         | Elemental Concentration $\mu\text{g}/\text{ccf}$ | Elemental Emission Rate $\text{gm}/\text{hr}$ |
| Volume (ml)            | 460.      | 950.              | 425.     |        | $E_R = 1.3 \times 10^3 \text{ kg/d (total)}$ |                                                  |                                               |
| Total Particulate (mg) | 57.16     | 18484.            | —        | 26.79  | $E_R = 5.9 \text{ kg/d (front end)}$         |                                                  |                                               |
| Ag Silver              | 4.6       | 5.7               | 4.3      | 5.0    | 20.0                                         | 0.21                                             | 0.06                                          |
| Al Aluminum            | 3800      | 95.0              | 130.     | 50.0   | 4100                                         | 42.                                              | 12.                                           |
| As Arsenic             | 2.8       | 0.95              | 1.3      | 0.5    | 5.9                                          | 0.06                                             | 0.02                                          |
| B Boron                | 1400      | 950.              | 1280     | 1000   | 4600                                         | 47.                                              | 13.                                           |
| Be Beryllium           | 2.8       | 1.9               | 2.1      | 1.0    | 7.8                                          | 0.08                                             | 0.02                                          |
| Cd Cadmium             | 2.8       | 1.9               | 2.1      | 2.0    | 8.8                                          | 0.09                                             | 0.03                                          |
| Co Cobalt              | 28.0      | 19.0              | 21.0     | 10.0   | 78.0                                         | 0.80                                             | 0.23                                          |
| Cr Chromium            | 28.0      | 19.0              | 21.0     | 20.0   | 88.0                                         | 0.90                                             | 0.26                                          |
| Cu Copper              | 14.0      | 9.5               | 13.0     | 10.0   | 46.0                                         | 0.47                                             | 0.13                                          |
| Fe Iron                | 41.0      | 86.0              | 170.     | 10.0   | 310.                                         | 3.2                                              | 0.91                                          |
| Ga Gallium             | 280.      | 190.              | 210.     | 200.   | 890.                                         | 9.1                                              | 2.6                                           |
| Ge Germanium           | 140.      | 95.0              | 130.     | 500.   | 860.                                         | 8.8                                              | 2.5                                           |
| Hg Mercury             | 4.6       | 5.7               | 4.2      | 10.0   | 25.0                                         | 0.26                                             | 0.07                                          |
| In Indium              | 140.      | 95.0              | 130.     | 100.   | 460.                                         | 4.7                                              | 1.3                                           |
| Li Lithium             | 4.6       | 5.7               | 4.3      | 3.0    | 18.0                                         | 0.18                                             | 0.03                                          |
| Mn Manganese           | 4.6       | 5.7               | 8.5      | 5.0    | 24.0                                         | 0.25                                             | 0.07                                          |
| Mo Molybdenum          | 28.0      | 19.0              | 21.0     | 20.0   | 88.0                                         | 0.90                                             | 0.26                                          |
| Ni Nickel              | 28.0      | 19.0              | 21.0     | 20.0   | 88.0                                         | 0.90                                             | 0.26                                          |
| Pb Lead                | 28.0      | 19.0              | 21.0     | 20.0   | 88.0                                         | 0.90                                             | 0.26                                          |
| Sb Antimony            | 46.0      | 48.0              | 43.0     | 20.0   | 160.                                         | 1.6                                              | 0.47                                          |
| Sc Scandium            | 46.0      | 57.0              | 43.0     | 50.0   | 200.                                         | 2.0                                              | 0.58                                          |
| Se Selenium            | 2.8       | 6.7               | 4.3      | 20.0   | 34.0                                         | 0.35                                             | 0.10                                          |
| Sn Tin                 | 140.      | 95.0              | 130.     | 50.0   | 410.                                         | 4.2                                              | 1.2                                           |
| Sr Strontium           | 4.6       | 5.7               | 4.3      | 5.0    | 20.0                                         | 0.20                                             | 0.06                                          |
| Te Tellurium           | 46.0      | 57.0              | 43.0     | 50.0   | 200.                                         | 2.0                                              | 0.58                                          |
| Ti Titanium            | 140.      | 95.0              | 130.     | 50.0   | 410.                                         | 4.2                                              | 1.2                                           |
| Tl Thallium            | 46.0      | 57.0              | 43.0     | 20.0   | 170.                                         | 1.7                                              | 0.48                                          |
| V Vanadium             | 46.0      | 57.0              | 43.0     | 4.0    | 150.                                         | 1.5                                              | 0.44                                          |
| Zn Zinc                | 41.0      | 90.0              | 3.4      | 3.0    | 140.                                         | 1.4                                              | 0.41                                          |

All elements except those in boxes ☐ are below the limit of detection.

Table V.10: Summary of Incinerator Stack Source Sampling Tests. Canterra-Rainbow Lake Plant; Test #1

| Sample Analyses        | Test No. 1 | Date                   | July 8, 1983 | RAINBOW LAKE |                                          |                                |                               |
|------------------------|------------|------------------------|--------------|--------------|------------------------------------------|--------------------------------|-------------------------------|
|                        |            |                        |              | Filter       | Total Elemental Weight ug                | Maximum Possible               |                               |
|                        |            |                        |              |              |                                          | Elemental Concentration ug/rcf | Elemental Emission Rate gm/hr |
| Sample From            | PAN        | Micrograms IMP. 1,2,3, | IMP. 4,5     |              |                                          |                                |                               |
| Volume (ml)            | 410.       | 1050.                  | 440.         |              | $E_R = 8.8 \times 10^3$ kg/d (total)     |                                |                               |
| Total Particulate (mg) | 60.77      | 56400.                 | —            | 75.20        | $E_R = 2.1 \times 10^1$ kg/d (front end) |                                |                               |
| Ag Silver              | 4.1        | 6.3                    | 4.4          | 5.0          | 20.                                      | 0.18                           | 0.13                          |
| Al Aluminum            | 120.       | 110.                   | 88.          | 50.          | 370.                                     | 3.3                            | 2.4                           |
| As Arsenic             | 1.2        | 1.1                    | 0.88         | 0.50         | 3.7                                      | 0.03                           | 0.02                          |
| B Boron                | 1230.      | 1050.                  | 880.         | 1000.        | 4200.                                    | 37.                            | 27.                           |
| Be Beryllium           | 1.6        | 2.1                    | 2.2          | 1.0          | 6.9                                      | 0.06                           | 0.04                          |
| Cd Cadmium             | 2.9        | 2.1                    | 2.2          | 2.0          | 9.2                                      | 0.08                           | 0.06                          |
| Co Cobalt              | 16.        | 21.                    | 22.          | 10.          | 69.                                      | 0.61                           | 0.45                          |
| Cr Chromium            | 29.        | 21.                    | 22.          | 20.          | 92.                                      | 0.81                           | 0.60                          |
| Cu Copper              | 12.        | 11.                    | 8.8          | 10.          | 42.                                      | 0.37                           | 0.27                          |
| Fe Iron                | 41.        | 42.                    | 40.          | 30.          | 150.                                     | 1.3                            | 0.97                          |
| Ga Gallium             | 290.       | 210.                   | 220.         | 200.         | 920.                                     | 8.1                            | 6.0                           |
| Ge Germanium           | 120.       | 110.                   | 88.          | 500.         | 820.                                     | 7.3                            | 5.3                           |
| Hg Mercury             | 8.2        | 6.3                    | 4.4          | 10.          | 29.                                      | 0.26                           | 0.19                          |
| In Indium              | 120.       | 110.                   | 88.          | 100.         | 418.                                     | 3.7                            | 2.7                           |
| Li Lithium             | 8.2        | 6.3                    | 4.4          | 3.0          | 22.                                      | 0.20                           | 0.14                          |
| Mn Manganese           | 8.2        | 6.3                    | 4.4          | 5.0          | 24.                                      | 0.21                           | 0.16                          |
| Mo Molybdenum          | 29.        | 21.                    | 22.          | 20.          | 92.                                      | 0.81                           | 0.60                          |
| Ni Nickel              | 29.        | 21.                    | 22.          | 20.          | 92.                                      | 0.81                           | 0.60                          |
| Pb Lead                | 29.        | 21.                    | 22.          | 20.          | 92.                                      | 0.81                           | 0.60                          |
| Sb Antimony            | 41.        | 42.                    | 40.          | 20.          | 140.                                     | 1.2                            | 0.91                          |
| Sc Scandium            | 82.        | 63.                    | 44.          | 50.          | 240.                                     | 2.1                            | 1.6                           |
| Se Selenium            | 2.9        | 7.4                    | 3.5          | 10.          | 24.                                      | 0.21                           | 0.16                          |
| Sn Tin                 | 120.       | 110.                   | 88.          | 50.          | 370.                                     | 3.3                            | 2.4                           |
| Sr Strontium           | 8.2        | 6.3                    | 4.4          | 5.0          | 24.                                      | 0.21                           | 0.16                          |
| Te Tellurium           | 82.        | 63.                    | 44.          | 50.          | 240.                                     | 2.1                            | 1.6                           |
| Ti Titanium            | 120.       | 110.                   | 88.          | 50.          | 370.                                     | 3.3                            | 2.4                           |
| Tl Thallium            | 82.        | 63.                    | 44.          | 20.          | 210.                                     | 1.9                            | 1.4                           |
| V Vanadium             | 82.        | 63.                    | 44.          | 4.0          | 190.                                     | 1.7                            | 1.2                           |
| Zn Zinc                | 4.1        | 3.2                    | 3.1          | 3.0          | 13.                                      | 0.12                           | 0.08                          |

All elements except those in boxes   are below the limit of detection.

Table V.11: Summary of Incinerator Stack Source  
Sampling Tests. Canterra-Rainbow  
Lake Plant; Test #2

| Sample<br>Analyses        | Test No. 2 | Date July 9, 1983 |             | RAINBOW LAKE |                                          |                                                          |                                        |
|---------------------------|------------|-------------------|-------------|--------------|------------------------------------------|----------------------------------------------------------|----------------------------------------|
|                           |            | Micrograms        |             |              | Total<br>Elemental<br>Weight<br>ug       | Maximum Possible<br>Elemental<br>Concentration<br>ug/rcf | Elemental<br>Emission<br>Rate<br>gm/hr |
| Sample<br>From            | P&N        | IMP.<br>1,2,3,    | IMP.<br>4,5 | Filter       |                                          |                                                          |                                        |
| Volume (ml)               | 450.       | 1145.             | 360.        |              | $E_R = 8.2 \times 10^3$ kg/d (total)     |                                                          |                                        |
| Total Particulate<br>(mg) | 102.       | 52862.            | —           | 77.76        | $E_R = 2.8 \times 10^1$ kg/d (front end) |                                                          |                                        |
| Ag Silver                 | 4.5        | 5.7               | 3.6         | 5.0          | 19.                                      | 0.16                                                     | 0.12                                   |
| Al Aluminum               | 140.       | 110.              | 110.        | 30.          | 410.                                     | 3.5                                                      | 2.6                                    |
| As Arsenic                | 1.4        | 1.1               | 1.1         | 0.50         | 4.1                                      | 0.04                                                     | 0.03                                   |
| B Boron                   | 1400.      | 1100.             | 1100.       | 1000.        | 4600.                                    | 39.                                                      | 30.                                    |
| Be Beryllium              | 2.7        | 2.3               | 2.2         | 1.0          | 8.2                                      | 0.07                                                     | 0.05                                   |
| Cd Cadmium                | 2.7        | 2.3               | 2.2         | 2.0          | 9.2                                      | 0.08                                                     | 0.06                                   |
| Co Cobalt                 | 27.        | 23.               | 22.         | 10.          | 82.                                      | 0.70                                                     | 0.53                                   |
| Cr Chromium               | 27.        | 23.               | 22.         | 20.          | 92.                                      | 0.79                                                     | 0.59                                   |
| Cu Copper                 | 14.        | 11.               | 11.         | 10.          | 46.                                      | 0.39                                                     | 0.30                                   |
| Fe Iron                   | 45.        | 160.              | 22.         | 30.          | 260.                                     | 2.2                                                      | 1.7                                    |
| Ga Gallium                | 270.       | 230.              | 220.        | 200.         | 920.                                     | 7.9                                                      | 5.9                                    |
| Ge Germanium              | 140.       | 110.              | 110.        | 500.         | 860.                                     | 7.4                                                      | 5.5                                    |
| Hg Mercury                | 4.5        | 5.7               | 3.6         | 10.          | 24.                                      | 0.21                                                     | 0.15                                   |
| In Indium                 | 140.       | 110.              | 110.        | 100.         | 460.                                     | 3.9                                                      | 3.0                                    |
| Li Lithium                | 4.5        | 5.7               | 3.6         | 3.0          | 17.                                      | 0.15                                                     | 0.11                                   |
| Mn Manganese              | 4.5        | 5.7               | 3.6         | 5.0          | 19.                                      | 0.16                                                     | 0.12                                   |
| Mo Molybdenum             | 27.        | 23.               | 22.         | 20.          | 92.                                      | 0.79                                                     | 0.59                                   |
| Ni Nickel                 | 27.        | 23.               | 22.         | 20.          | 92.                                      | 0.79                                                     | 0.59                                   |
| Pb Lead                   | 27.        | 23.               | 22.         | 20.          | 92.                                      | 0.79                                                     | 0.59                                   |
| Sb Antimony               | 45.        | 46.               | 36.         | 20.          | 150.                                     | 1.3                                                      | 0.96                                   |
| Sc Scandium               | 45.        | 57.               | 36.         | 50.          | 190.                                     | 1.6                                                      | 1.2                                    |
| Se Selenium               | 2.7        | 9.2               | 2.2         | 10.          | 24.                                      | 0.21                                                     | 0.15                                   |
| Sn Tin                    | 140.       | 110.              | 110.        | 50.          | 410.                                     | 3.5                                                      | 2.6                                    |
| Sr Strontium              | 4.5        | 5.7               | 3.6         | 5.0          | 19.                                      | 0.16                                                     | 0.12                                   |
| Te Tellurium              | 45.        | 57.               | 36.         | 50.          | 190.                                     | 1.6                                                      | 1.2                                    |
| Ti Titanium               | 140.       | 110.              | 110.        | 50.          | 410.                                     | 3.5                                                      | 2.6                                    |
| Tl Thallium               | 45.        | 57.               | 36.         | 20.          | 160.                                     | 1.4                                                      | 1.0                                    |
| V Vanadium                | 45.        | 57.               | 36.         | 4.0          | 140.                                     | 1.2                                                      | 0.90                                   |
| Zn Zinc                   | 4.1        | 17.               | 3.2         | 3.0          | 27.                                      | 0.23                                                     | 0.17                                   |

All elements except those in boxes ☐ are below the limit of detection.



Table V.12: Summary of Incinerator Stack Source Sampling Tests. Canterra-Rainbow Lake Plant; Test #3

| Sample Analyses        | Test No. 3  |            | Date July 10, 1983 |        | RAINBOW LAKE              |                                                  |                                        |
|------------------------|-------------|------------|--------------------|--------|---------------------------|--------------------------------------------------|----------------------------------------|
|                        | Sample From | Micrograms |                    | Filter | Total Elemental Weight ug | Maximum Elemental Concentration ug/rcf           | Possible Elemental Emission Rate gm/hr |
|                        |             | P&N        | IMP. 1,2,3,        |        |                           |                                                  |                                        |
| Volume (ml)            | 470.        |            | 870.               | 320.   |                           | $E_R = 8.1 \times 10^3 \text{ kg/d (total)}$     |                                        |
| Total Particulate (mg) | 58.64       |            | 52628.             | —      | 75.29                     | $E_R = 2.0 \times 10^1 \text{ kg/d (front end)}$ |                                        |
| Ag Silver              | 4.7         |            | 6.1                | 6.4    | 5.0                       | 22.                                              | 0.19                                   |
| Al Aluminum            | 140.        |            | 3900.              | 96.    | 50.                       | 4200.                                            | 36.                                    |
| As Arsenic             | 1.4         |            | 0.87               | 0.96   | 0.50                      | 3.7                                              | 0.03                                   |
| B Boron                | 1400.       |            | 870.               | 960.   | 1000.                     | 4200.                                            | 36.                                    |
| Be Beryllium           | 2.8         |            | 2.6                | 2.2    | 1.0                       | 8.6                                              | 0.07                                   |
| Cd Cadmium             | 2.8         |            | 2.6                | 2.2    | 2.0                       | 9.6                                              | 0.08                                   |
| Co Cobalt              | 28.         |            | 26.                | 22.    | 10.                       | 86.                                              | 0.73                                   |
| Cr Chromium            | 28.         |            | 35.                | 22.    | 20.                       | 95.                                              | 0.81                                   |
| Cu Copper              | 14.         |            | 8.7                | 9.6    | 10.                       | 42.                                              | 0.36                                   |
| Fe Iron                | 94.         |            | 150.               | 32.    | 20.                       | 300.                                             | 2.6                                    |
| Ga Gallium             | 280.        |            | 260.               | 220.   | 200.                      | 960.                                             | 8.2                                    |
| Ge Germanium           | 140.        |            | 87.                | 96.    | 500.                      | 820.                                             | 7.0                                    |
| Hg Mercury             | 4.7         |            | 6.1                | 6.4    | 10.                       | 27.                                              | 0.23                                   |
| In Indium              | 140.        |            | 87.                | 96.    | 100.                      | 420.                                             | 3.6                                    |
| Li Lithium             | 4.7         |            | 6.1                | 6.4    | 3.0                       | 20.                                              | 0.17                                   |
| Mn Manganese           | 4.7         |            | 6.1                | 6.4    | 5.0                       | 22.                                              | 0.19                                   |
| Mo Molybdenum          | 28.         |            | 26.                | 22.    | 20.                       | 96.                                              | 0.82                                   |
| Ni Nickel              | 28.         |            | 26.                | 22.    | 20.                       | 96.                                              | 0.82                                   |
| Pb Lead                | 28.         |            | 26.                | 22.    | 20.                       | 96.                                              | 0.82                                   |
| Sb Antimony            | 47.         |            | 44.                | 32.    | 20.                       | 140.                                             | 1.2                                    |
| Sc Scandium            | 47.         |            | 61.                | 64.    | 50.                       | 220.                                             | 1.9                                    |
| Se Selenium            | 2.8         |            | 7.0                | 2.2    | 10.                       | 22.                                              | 0.19                                   |
| Sn Tin                 | 140.        |            | 87.                | 96.    | 50.                       | 370.                                             | 3.2                                    |
| Sr Strontium           | 4.7         |            | 6.1                | 6.4    | 5.0                       | 22.                                              | 0.19                                   |
| Te Tellurium           | 47.         |            | 61.                | 64.    | 50.                       | 220.                                             | 1.9                                    |
| Ti Titanium            | 140.        |            | 87.                | 96.    | 50.                       | 370.                                             | 3.2                                    |
| Tl Thallium            | 47.         |            | 61.                | 64.    | 20.                       | 190.                                             | 1.6                                    |
| V Vanadium             | 47.         |            | 61.                | 64.    | 4.0                       | 180.                                             | 1.5                                    |
| Zn Zinc                | 4.2         |            | 4.4.               | 3.2    | 3.0                       | 15.                                              | 0.13                                   |

All elements except those in boxes are below the limit of detection.

Table V.13: Summary of Incinerator Stack Source Sampling Tests. Esso-Quirk Creek Plant; Test #1

| Sample Analyses        | Test No. 1 | Date November 23, 1983 |        |        |        | QUIRK CREEK<br>Maximum Possible          |                                |                               |
|------------------------|------------|------------------------|--------|--------|--------|------------------------------------------|--------------------------------|-------------------------------|
|                        |            | Micrograms             |        |        |        | Total Elemental Weight ug                | Elemental Concentration ug/ref | Elemental Emission Rate gm/hr |
| Sample From            | P&N        | IMP. 1,2,3,            | IMP. 4 | IMP. 5 | Filter |                                          |                                |                               |
| Volume (ml)            | 380.       | 1215.                  | 160.   | 160.   |        | $E_R = 1.8 \times 10^4$ kg/d (total)     |                                |                               |
| Total Particulate (mg) | 104.8      | 29548.                 | —      | —      | 48.53  | $E_R = 9.1 \times 10^1$ kg/d (front end) |                                |                               |
| Ag Silver              | 7.6        | 5.6                    | 8.0    | 8.0    | 6.0    | 35.                                      | 0.41                           | 0.87                          |
| Al Aluminum            | 150.       | 110.                   | 160.   | 160.   | 50.    | 630.                                     | 7.4                            | 16.                           |
| As Arsenic             | 3.0        | 2.2                    | 3.2    | 3.2    | 2.0    | 14.                                      | 0.16                           | 0.34                          |
| B Boron                | 1500.      | 1100.                  | 1600.  | 1600.  | 1000.  | 6800.                                    | 80.                            | 170.                          |
| Be Beryllium           | 3.0        | 2.2                    | 3.2    | 3.2    | 1.0    | 13.                                      | 0.15                           | 0.32                          |
| Cd Cadmium             | 3.0        | 6.7                    | 3.2    | 3.2    | 2.0    | 18.                                      | 0.21                           | 0.44                          |
| Co Cobalt              | 30.        | 22.                    | 32.    | 32.    | 10.    | 130.                                     | 1.5                            | 3.2                           |
| Cr Chromium            | 30.        | 33.                    | 32.    | 32.    | 20.    | 150.                                     | 1.7                            | 3.7                           |
| Cu Copper              | 15.        | 45.                    | 16.    | 16.    | 10.    | 100.                                     | 1.2                            | 2.5                           |
| Fe Iron                | 30.        | 120.                   | 16.    | 16.    | 40.    | 220.                                     | 2.6                            | 5.4                           |
| Ga Gallium             | 300.       | 220.                   | 320.   | 320.   | 100.   | 1200.                                    | 15.                            | 32.                           |
| Ge Germanium           | 760.       | 560.                   | 800.   | 800.   | 500.   | 3400.                                    | 40.                            | 84.                           |
| Hg Mercury             | 1.4        | 1.1                    | 1.6    | 1.6    | 680.   | 690.                                     | 8.1                            | 17.                           |
| In Indium              | 300.       | 220.                   | 320.   | 320.   | 100.   | 1300.                                    | 15.                            | 32.                           |
| Li Lithium             | 7.6        | 5.6                    | 8.0    | 8.0    | 2.0    | 31.                                      | 0.37                           | 0.77                          |
| Mn Manganese           | 7.6        | 5.6                    | 8.0    | 8.0    | 6.0    | 35.                                      | 0.41                           | 0.87                          |
| Mo Molybdenum          | 76.        | 56.                    | 80.    | 80.    | 50.0   | 340.                                     | 4.0                            | 8.4                           |
| Ni Nickel              | 30.        | 22.                    | 32.    | 32.    | 10.    | 130.                                     | 1.5                            | 3.2                           |
| Pb Lead                | 30.        | 22.                    | 32.    | 32.    | 20.    | 86.                                      | 1.0                            | 2.1                           |
| Sb Antimony            | 76.        | 45.                    | 64.    | 64.    | 20.    | 270.                                     | 3.2                            | 6.7                           |
| Sc Scandium            | 76.        | 56.                    | 80.    | 80.    | 30.    | 320.                                     | 3.8                            | 7.9                           |
| Se Selenium            | 3.0        | 2.2                    | 3.2    | 3.2    | 20.    | 14.                                      | 0.16                           | 0.34                          |
| Sn Tin                 | 150.       | 110.                   | 160.   | 160.   | 50.    | 630.                                     | 7.4                            | 16.                           |
| Sr Strontium           | 7.6        | 5.6                    | 8.0    | 8.8    | 6.0    | 36.                                      | 0.42                           | 0.89                          |
| Te Tellurium           | 76.        | 56.                    | 80.    | 80.    | 60.    | 350.                                     | 4.1                            | 8.7                           |
| Ti Titanium            | 150.       | 110.                   | 160.   | 160.   | 50.    | 630.                                     | 7.4                            | 16.                           |
| Tl Thallium            | 76.        | 56.                    | 80.    | 80.    | 60.    | 350.                                     | 4.1                            | 8.7                           |
| V Vanadium             | 76.        | 56.                    | 80.    | 80.    | 60.    | 350.                                     | 4.1                            | 8.7                           |
| Zn Zinc                | 23.        | 12.                    | 4.8    | 35.    | 2.0    | 77.                                      | 0.93                           | 1.9                           |

All elements except those in boxes are below the limit of detection.

Table V.14: Summary of Incinerator Stack Source Sampling Tests. Esso-Quirk Creek Plant; Test #2

| Sample Analyses        | Test No. 2 | Date        | November 24, 1983 |        | QUIRK CREEK |                           |                                                 |                               |
|------------------------|------------|-------------|-------------------|--------|-------------|---------------------------|-------------------------------------------------|-------------------------------|
|                        |            | Micrograms  |                   |        |             | Total Elemental Weight ug | Maximum Possible Elemental Concentration ug/rcf | Elemental Emission Rate gm/hr |
| Sample From            | P&N        | IMP. 1,2,3, | 4                 | IMP. 5 | Filter      |                           |                                                 |                               |
| Volume (ml)            | 320.       | 1155.       | 230.              | 120.   |             | $E_R = 1.9 \times 10^4$   | kg/d (total)                                    |                               |
| Total Particulate (mg) | 57.52      | 31060.      | —                 | —      | 25.65       | $E_R = 5.0 \times 10^1$   | kg/d (front end)                                |                               |
| Ag Silver              | 9.6        | 5.3         | 6.9               | 6.0    | 6.0         | 34.                       | 0.42                                            | 0.86                          |
| Al Aluminum            | 160.       | 105.        | 120.              | 120.   | 50.         | 560.                      | 6.9                                             | 14.                           |
| As Arsenic             | 3.2        | 2.1         | 2.3               | 2.4    | 2.0         | 12.                       | 0.15                                            | 0.30                          |
| B Boron                | 1600.      | 1100.       | 1200.             | 1200.  | 1000.       | 6100.                     | 75.                                             | 150.                          |
| Be Beryllium           | 3.2        | 2.1         | 2.3               | 2.4    | 1.0         | 11.                       | 0.13                                            | 0.28                          |
| Cd Cadmium             | 3.2        | 2.1         | 2.3               | 2.4    | 2.0         | 12.                       | 0.15                                            | 0.30                          |
| Co Cobalt              | 32.        | 21.         | 23.               | 24.    | 10.         | 110.                      | 1.3                                             | 2.8                           |
| Cr Chromium            | 32.        | 42.         | 23.               | 24.    | 20.         | 140.                      | 1.7                                             | 3.5                           |
| Cu Copper              | 16.        | 11.         | 12.               | 23.    | 10.         | 72.                       | 0.88                                            | 1.8                           |
| Fe Iron                | 16.        | 42.         | 12.               | 12.    | 20.         | 100.                      | 1.3                                             | 2.6                           |
| Ga Gallium             | 320.       | 210.        | 230.              | 240.   | 100.        | 1100.                     | 14.                                             | 29.                           |
| Ge Germanium           | 320.       | 530.        | 230.              | 600.   | 500.        | 2200.                     | 27.                                             | 55.                           |
| Hg Mercury             | 1.9        | 1.1         | 1.4               | 1.2    | 1.0         | 6.5                       | 0.08                                            | 0.16                          |
| In Indium              | 320.       | 210.        | 230.              | 240.   | 100.        | 1100.                     | 14.                                             | 28.                           |
| Li Lithium             | 9.6        | 5.3         | 6.9               | 6.0    | 2.0         | 30.                       | 0.37                                            | 0.76                          |
| Mn Manganese           | 9.6        | 5.3         | 6.9               | 6.0    | 6.0         | 34.                       | 0.42                                            | 0.86                          |
| Mo Molybdenum          | 80.        | 53.         | 58.               | 60.    | 50.         | 310.                      | 3.7                                             | 7.7                           |
| Ni Nickel              | 32.        | 21.         | 23.               | 24.    | 10.         | 90.                       | 1.1                                             | 2.3                           |
| Pb Lead                | 32.        | 21.         | 23.               | 24.    | 20.         | 100.                      | 1.2                                             | 2.5                           |
| Sb Antimony            | 64.        | 42.         | 46.               | 48.    | 20.         | 220.                      | 2.7                                             | 5.5                           |
| Sc Scandium            | 96.        | 53.         | 69.               | 60.    | 30.         | 250.                      | 3.1                                             | 6.3                           |
| Se Selenium            | 3.2        | 2.1         | 2.3               | 2.4    | 2.0         | 12.                       | 0.15                                            | 0.30                          |
| Sn Tin                 | 160.       | 110.        | 120.              | 120.   | 50.         | 560.                      | 6.9                                             | 14.                           |
| Sr Strontium           | 9.6        | 5.3         | 6.9               | 6.0    | 8.0         | 36.                       | 0.44                                            | 0.91                          |
| Te Tellurium           | 96.        | 53.         | 69.               | 60.    | 60.         | 340.                      | 4.2                                             | 8.6                           |
| Ti Titanium            | 160.       | 110.        | 120.              | 120.   | 50.         | 560.                      | 6.9                                             | 14.                           |
| Tl Thallium            | 96.        | 53.         | 69.               | 60.    | 60.         | 340.                      | 4.2                                             | 8.6                           |
| V Vanadium             | 96.        | 53.         | 69.               | 60.    | 60.         | 340.                      | 4.2                                             | 8.6                           |
| Zn Zinc                | 6.4        | 3.2         | 6.9               | 3.6    | 2.0         | 22.                       | 0.27                                            | 0.55                          |

All elements except those in boxes are below the limit of detection.

Table V.15: Summary of Incinerator Stack Source Sampling Tests. Esso-Quirk Creek Plant; Test #3

| Sample Analyses        | Test No. 3 | Date November 25, 1983 |        |        |        | QUIRK CREEK               |                                                 |                               |
|------------------------|------------|------------------------|--------|--------|--------|---------------------------|-------------------------------------------------|-------------------------------|
|                        |            | Micrograms             |        |        |        | Total Elemental Weight ug | Maximum Possible Elemental Concentration ug/rcf | Elemental Emission Rate gm/hr |
| Sample From            | P&N        | D.P. 1,2,3,            | D.P. 4 | D.P. 5 | Filter |                           |                                                 |                               |
| Volume (ml)            | 380.       | 1120.                  | 240.   | 240.   |        | $E_R = 9.0 \times 10^2$   | $\text{kg/d}$ (total)                           |                               |
| Total Particulate (mg) | 56.91      | 1411.                  | —      | —      | 18.65  | $E_R = 4.6 \times 10^1$   | $\text{kg/d}$ (front end)                       |                               |
| Ag Silver              | 11.        | 5.1                    | 7.2    | 7.2    | 6.0    | 37.                       | 0.44                                            | 0.94                          |
| Al Aluminum            | 190.       | 100.                   | 140.   | 120.   | 50.    | 600.                      | 7.2                                             | 15.                           |
| As Arsenic             | 3.8        | 2.0                    | 2.4    | 2.4    | 2.0    | 13.                       | 0.16                                            | 0.33                          |
| B Boron                | 1900.      | 1000.                  | 1200.  | 1200.  | 1000.  | 6300.                     | 76.                                             | 160.                          |
| Be Beryllium           | 3.8        | 2.0                    | 2.4    | 2.4    | 1.0    | 12.                       | 0.14                                            | 0.30                          |
| Cd Cadmium             | 3.8        | 2.0                    | 2.4    | 2.4    | 2.0    | 13.                       | 0.16                                            | 0.33                          |
| Co Cobalt              | 38.        | 20.                    | 24.    | 24.    | 10.    | 120.                      | 1.4                                             | 3.0                           |
| Cr Chromium            | 38.        | 20.                    | 24.    | 24.    | 20.    | 130.                      | 1.6                                             | 3.3                           |
| Cu Copper              | 19.        | 10.                    | 12.    | 12.    | 10.    | 63.                       | 0.76                                            | 1.6                           |
| Fe Iron                | 57.        | 50.                    | 24.    | 12.    | 10.    | 160.                      | 1.9                                             | 3.9                           |
| Ga Gallium             | 380.       | 200.                   | 240.   | 240.   | 100.   | 1200.                     | 14.                                             | 30.                           |
| Ge Germanium           | 380.       | 510.                   | 240.   | 240.   | 500.   | 1900.                     | 23.                                             | 48.                           |
| Hg Mercury             | 2.3        | 1.0                    | 1.4    | 1.4    | 1.0    | 7.1                       | 0.09                                            | 0.18                          |
| In Indium              | 380.       | 200.                   | 240.   | 240.   | 100.   | 1200.                     | 14.                                             | 30.                           |
| Li Lithium             | 11.        | 5.1                    | 7.2    | 7.2    | 2.0    | 33.                       | 0.40                                            | 0.84                          |
| Mn Manganese           | 11.        | 5.1                    | 7.2    | 7.2    | 6.0    | 37.                       | 0.44                                            | 0.94                          |
| Mo Molybdenum          | 95.        | 51.                    | 110.   | 60.    | 50.    | 370.                      | 4.4                                             | 9.3                           |
| Ni Nickel              | 38.        | 20.                    | 24.    | 24.    | 10.    | 120.                      | 1.4                                             | 3.0                           |
| Pb Lead                | 38.        | 20.                    | 24.    | 24.    | 20.    | 130.                      | 1.6                                             | 3.3                           |
| Sb Antimony            | 76.        | 41.                    | 48.    | 48.    | 20.    | 230.                      | 2.8                                             | 5.8                           |
| Sc Scandium            | 110.       | 51.                    | 72.    | 72.    | 30.    | 340.                      | 4.1                                             | 8.6                           |
| Se Selenium            | 3.8        | 2.0                    | 2.4    | 2.4    | 2.0    | 13.                       | 0.16                                            | 0.33                          |
| Sn Tin                 | 190.       | 100.                   | 140.   | 120.   | 50.    | 600.                      | 7.2                                             | 15.                           |
| Sr Strontium           | 11.        | 5.1                    | 7.2    | 7.2    | 6.0    | 37.                       | 0.44                                            | 0.94                          |
| Te Tellurium           | 110.       | 51.                    | 72.    | 72.    | 60.    | 370.                      | 4.4                                             | 9.4                           |
| Ti Titanium            | 190.       | 100.                   | 120.   | 120.   | 50.    | 580.                      | 7.0                                             | 15.                           |
| Tl Thallium            | 110.       | 51.                    | 72.    | 72.    | 60.    | 370.                      | 4.4                                             | 9.4                           |
| V Vanadium             | 110.       | 51.                    | 72.    | 72.    | 60.    | 370.                      | 4.4                                             | 9.4                           |
| Zn Zinc                | 76.        | 38.0                   | 34.    | 9.6    | 2.0    | 160.                      | 1.9                                             | 4.1                           |

All elements except those in boxes ☐ are below the limit of detection.

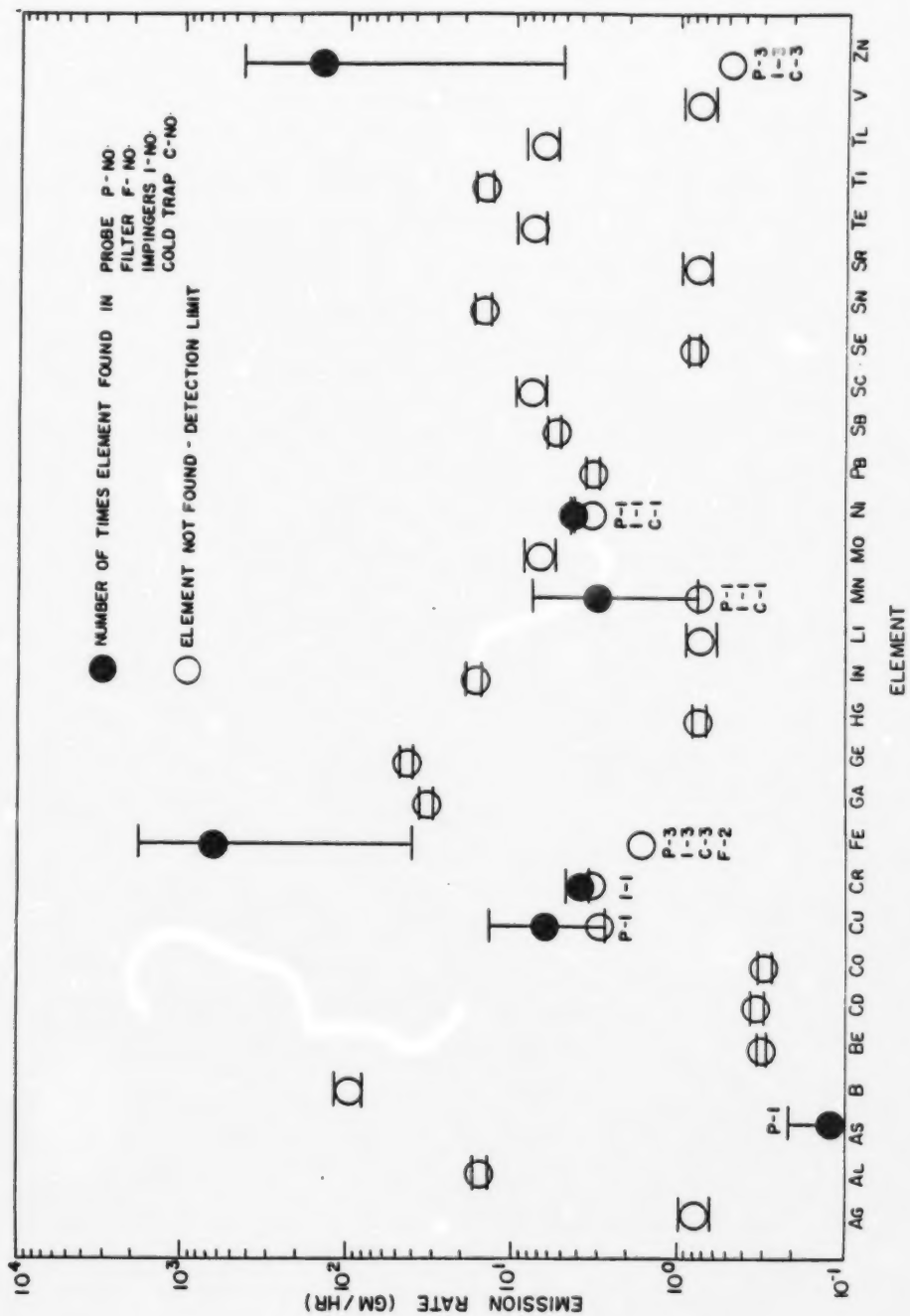


Figure V.1: Maximum Possible Emission Rates of All Elements in Canadian Superior-Harmattan Incinerator Stack Gases

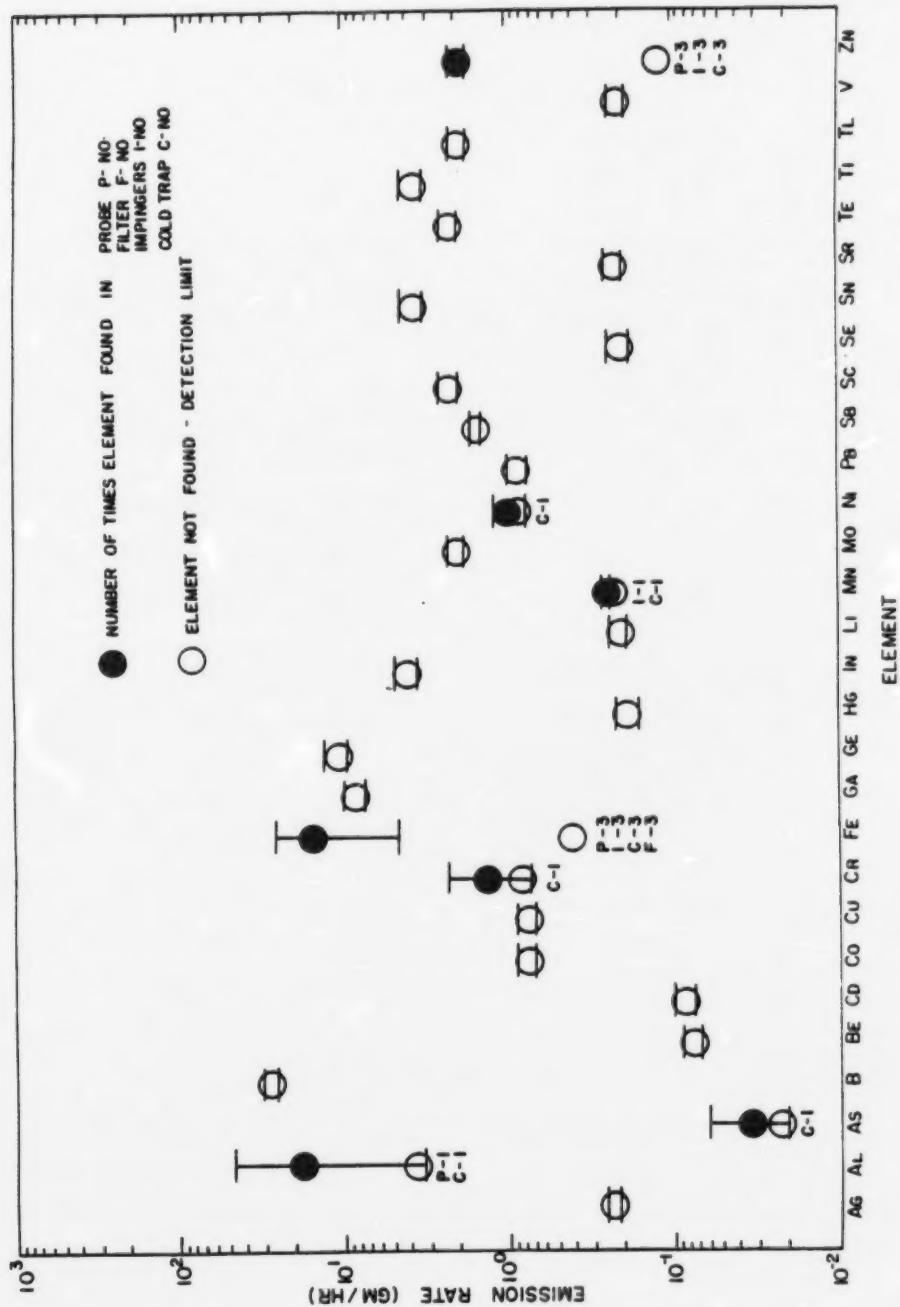


Figure V.2: Maximum Possible Emission Rates of All Elements in Gulf-Revis Incinerator Stack Gases

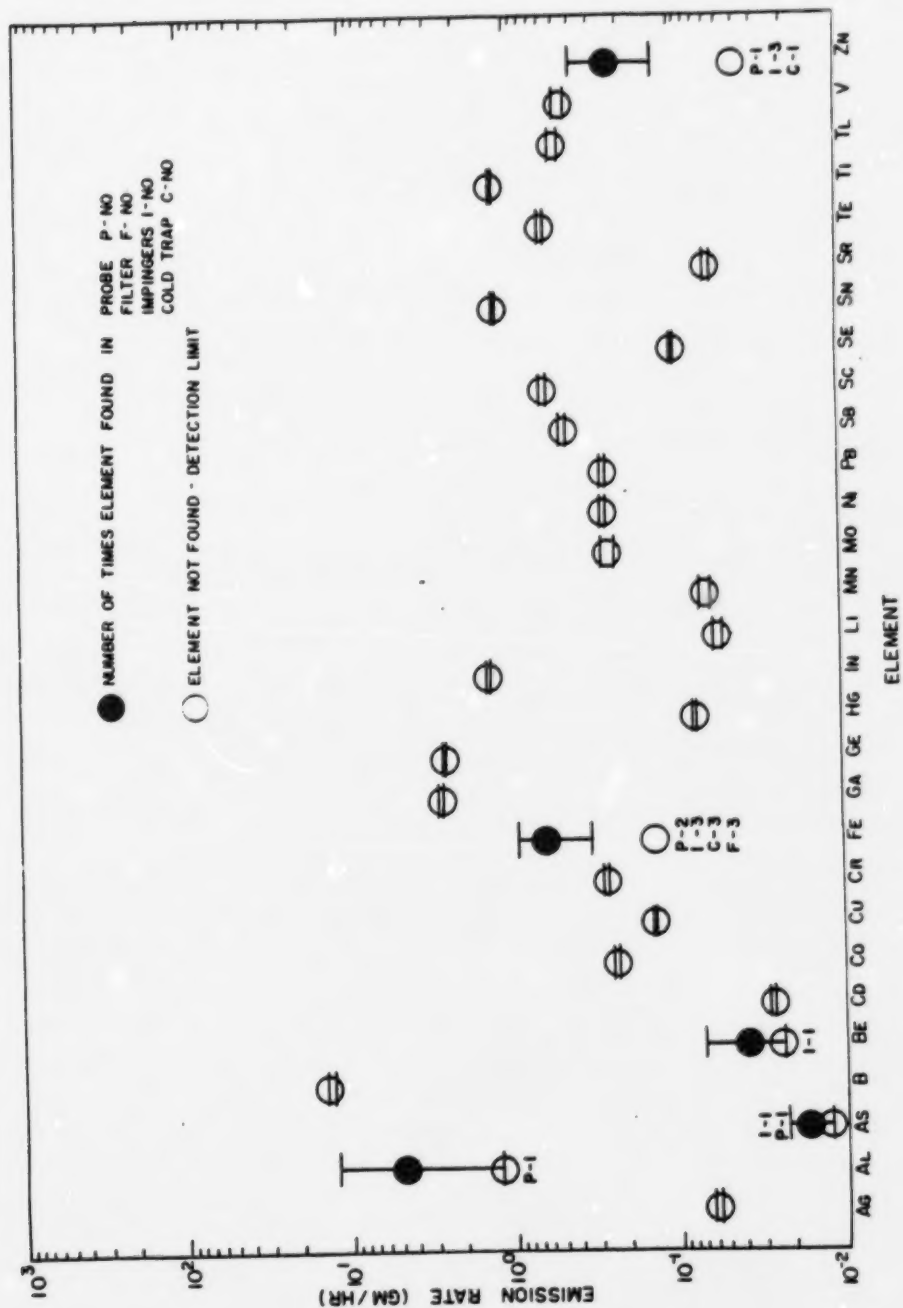


Figure V.3: Maximum Possible Emission Rates of All Elements in Petro Canada-Gold Creek Incinerator Stack Gases



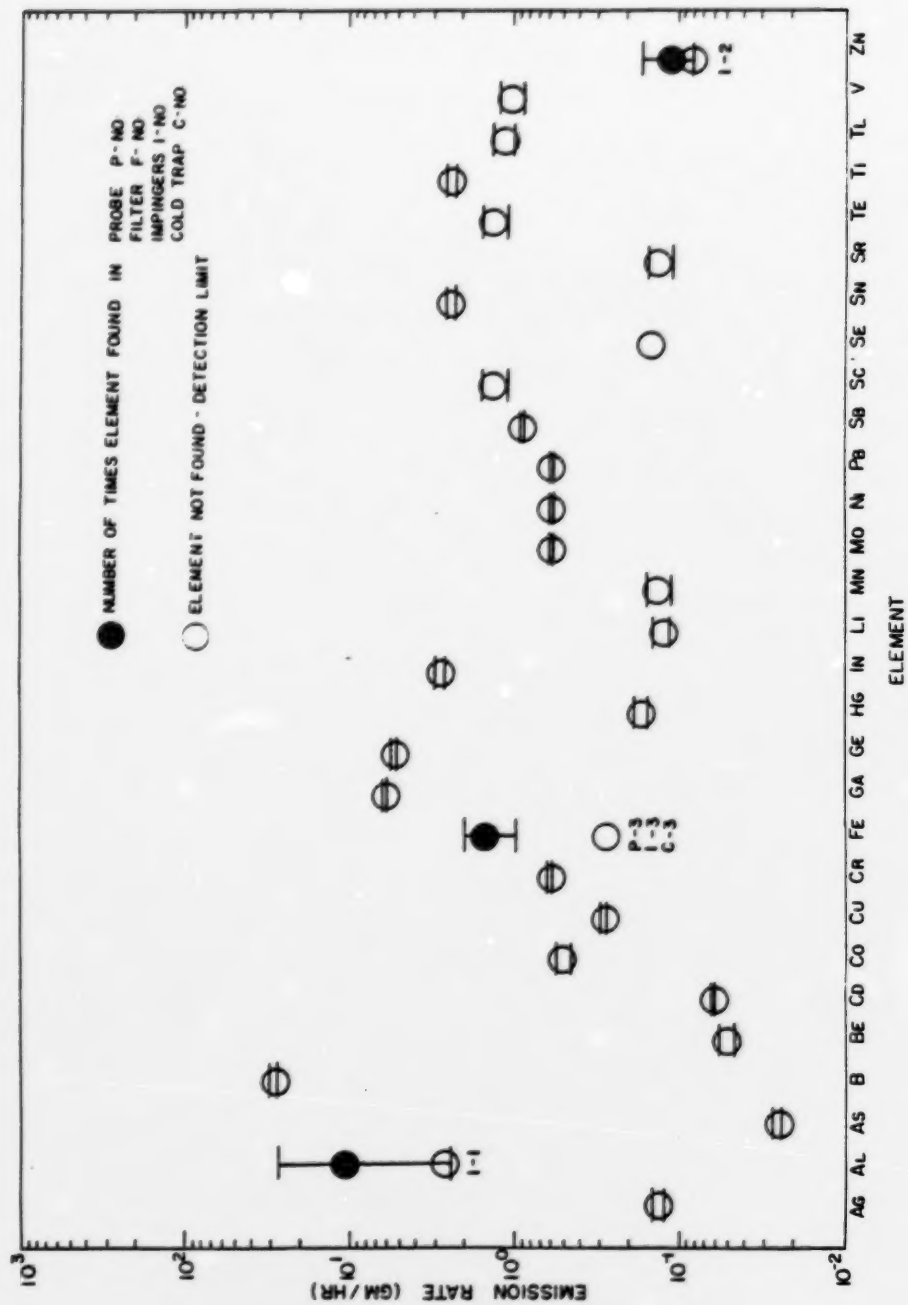


Figure V.4: Maximum Possible Emission Rates of All Elements in Canterra-Rainbow Lake Incinerator Stack Cases

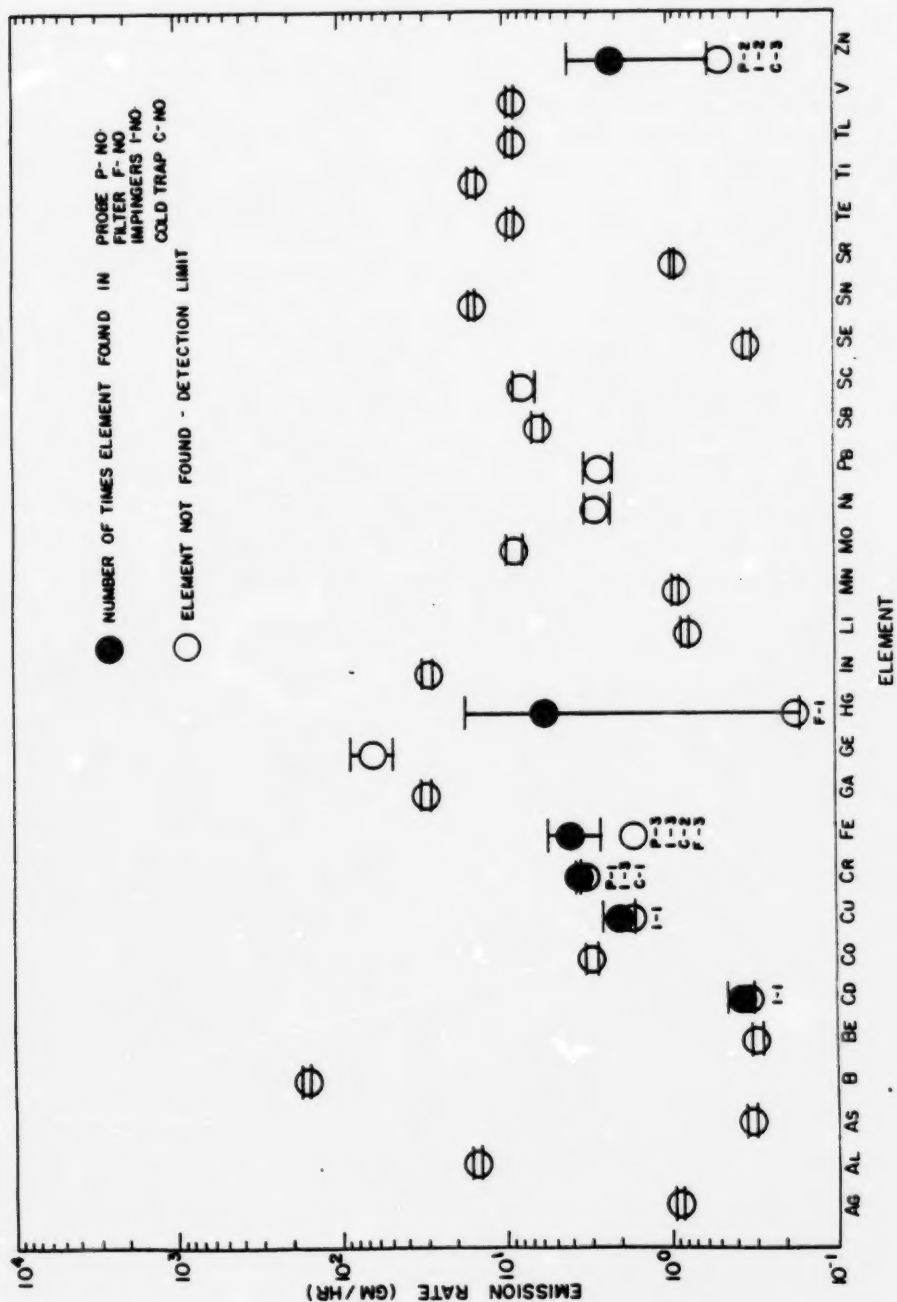


Figure V.5: Maximum Possible Emission Rates of All Elements in Esso-Quirk Creek Incinerator Stack Gases

presence at the limits of detection (LOD) values. In Figures V.1 to V.5, such mean emission rates are represented by open circles.

Emission rates of elements whose presence was detected, in at least one of the 4 samples recovered from the sampling train parts after each test, were evaluated from measured and limit of detection concentrations. These rates are depicted by solid circles. Open circles below the solid ones provide measures of mean maximum possible emission rates corresponding to LOD values only.

In Figures V.1 to V.5 all mean emission rates are bracketed to indicate the upper and lower bounds of measured or LOD magnitudes for each element under consideration.

An examination of Tables V.1 to V.15 and Figures V.1 to V.5 suggests that there is a definite need to distinguish clearly between elements whose presence was "detected" and those whose presence was "established".

An element has been classified as "detected" if an ultimate analysis solution absorbance exceeded the value corresponding to the LOD concentrations as well as the laboratory blank values for that species at least once. On the other hand, the presence of an element was "established" if that element was "detected" in more than one-half of the tests or at a concentration 3 times the limit of detection (LOD).

An appreciation of the difference between a "detected" and an "established" presence of an element can be realized in terms of the values in Tables V.13 to V.15, pertaining to the

determination of strontium. The summary of pertinent data in Table V.16 shows that the presence of strontium was "detected" once during analysis of the 4 samples recovered from the sampling train, after each of the 3 independent tests with the borosilicate glass lined probe.

A comparison of the masses of strontium collected in different parts of the sampling train and resultant evaluations of stack gas concentrations and emission rates for Test #2 and Test #3 shows that although the presence of strontium was never "detected" during Test #3, the respective magnitudes are, with the exception of the filter catch, generally higher than those corresponding to Test #2. Although the Test #2 emission rate (0.91 g/h) is lower than the 0.94 g/h value calculated for Test #3, it is reported as exceeding the limit of detection for that test. On the other hand, the Test #3 rate is considered as the maximum value that could be expected if strontium was present in the stack gases at levels resulting in ultimate resolution concentrations equal to the Limit of Detection for instrumental assessment.

Although the presence of strontium was "detected" in Test #2 neither the number of "detections" nor the concentration at which detection was made satisfy the criteria for "establishment" of the presence of strontium in the Esso-Quirk Creek Gas Plant Incinerator Stack gases. As a result, strontium would not be included in Table 5.3.

Table V.16 Summary of Strontium Determinations at the Esso-Quirk Creek Gas Plant (Borosilicate Glass Liner)

| Test | Probe & Nozzle (Washes) | Mass of Strontium Collected (ug) |     |     |        |                      | Maximum Possible Strontium Stack Gas |                      | Comments                                                                     |
|------|-------------------------|----------------------------------|-----|-----|--------|----------------------|--------------------------------------|----------------------|------------------------------------------------------------------------------|
|      |                         | 1,2,3                            | 4   | 5   | Filter | Total Sampling Train | Concentration (ug/rcf)               | Emission Rate (g/hr) |                                                                              |
| #1   | 7.6                     | 5.6                              | 8.0 | 8.8 | 6.0    | 36                   | 0.42                                 | 0.89                 | No detection: only LOD levels reported                                       |
| #2   | 9.6                     | 5.3                              | 6.9 | 6.0 | 8.0    | 36                   | 0.44                                 | 0.91                 | Strontium detected on filter: emission rate based on measured and LOD values |
| #3   | 11                      | 5.1                              | 7.2 | 7.2 | 6.0    | 37                   | 0.44                                 | 0.94                 | emission rate based on LOD values                                            |

☐ Element positively detected

The apparent contradiction created by lower emission rates being reported as measured values while higher ones are considered to be hypothetical upper limits can be resolved by reference to Figure V.6. This schematic illustrates the evaluation of the emission rate of some arbitrary element "X" for which the instrumental limit of detection (LOD) value is assumed to be 1 ug/L.

Steps #1 and #2 involve analysis of aliquots of different volumes of field solutions (A = 400 mL vs. B = 600 mL) which captured element "X" from different volumes of stack gases (100 m<sup>3</sup> vs. 150 m<sup>3</sup>). Since the concentrations of both aliquots are below the instrumental limit of detection for element "X", they must be reported as being less than 1 ug/L. On this basis, both samples overestimate the true emission rate considerably.

Concentration of the field liquids (A and B) to 100 mL before analysis according to Steps #3 and #4, provides one solution (C) for which the concentration will be reported as being less than 1 ug/L. The resultant emission rate of 1 ug/s is still an overestimate of the true value. It would be reported as a maximum possible emission rate. However, ultimate solution (D) provides a measurable concentration from which the true emission rate can be evaluated as 0.8 ug/s.

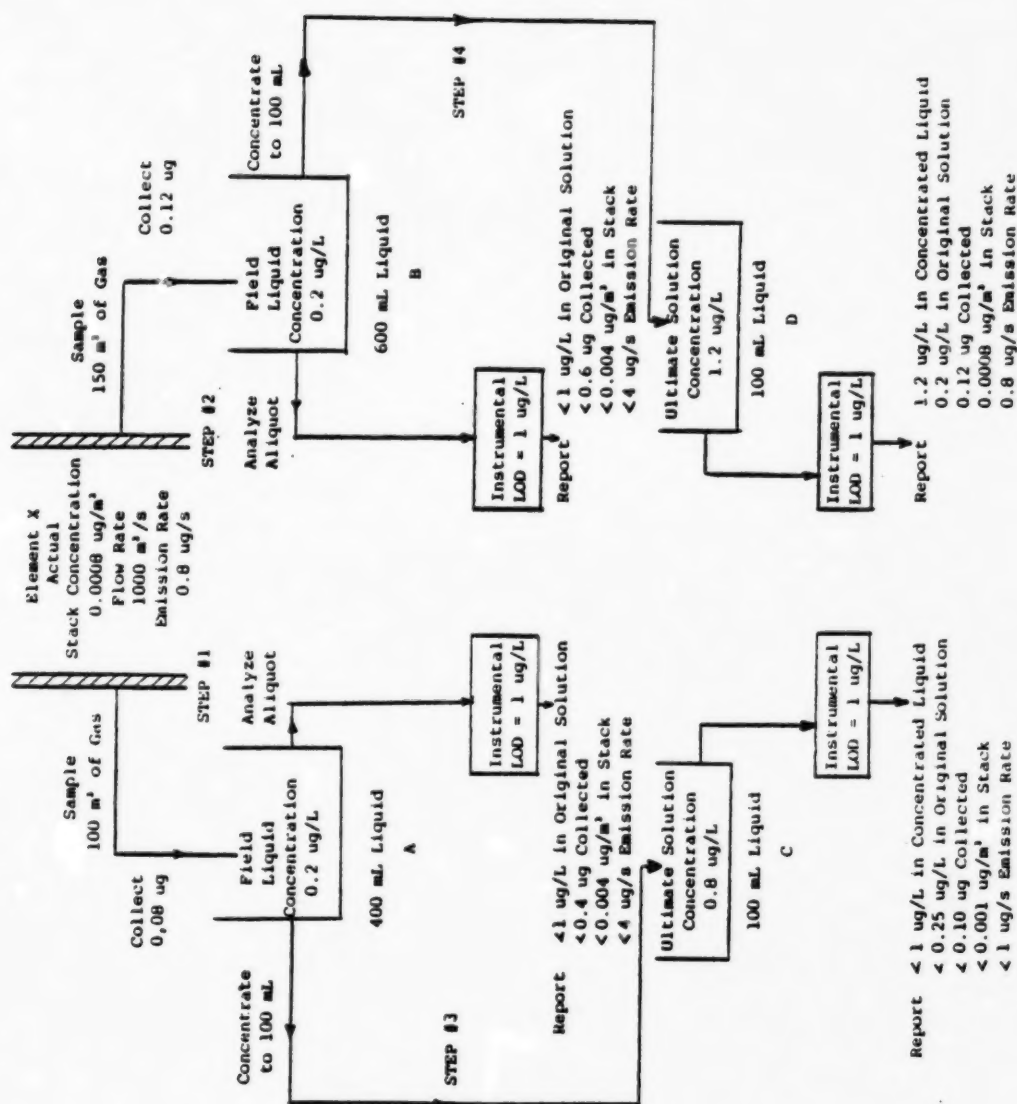


Figure V.6 Effect of Preconcentration on Reported Emission Rates